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THE PROCEEDINGS

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UNITED STATES NAVAL INSTITUTE.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE MINE DEFENSE OF SANTIAGO HARBOR.

LIEUTENANT E. E. CAPEHART, U. S. Navy.

The entrance to the harbor of Santiago, where ships of any considerable draft can navigate, is scarcely more than one hundred and twenty-five yards wide, in its narrowest places, and in order to render it hazardous for our ships to attempt to force a passage the channel was mined with both electrical and contact mines; the former of the Latimer Clark type, containing two hundred and twenty-six kilos. of gun-cotton, and the latter the Bustamente mine, containing forty-five kilos. of gun-cotton.

The electrical, or observation, mines, were planted in mid-channel, and were controlled, at first, by two stations on the west, or Socapa bank, one on Cay Smith, and one at Estrella Cove on the east bank. The station at Estrella Cove and the inner one on the Socapa bank were in the best possible positions for protection, and could have been operated even should the banks have been swept by the guns of our fleet. In the cove just behind the Morro, the operator could, in almost perfect security, observe his mine field until the ships to be destroyed were almost abeam

of him, and could operate his mines long before he could be discovered.

At the Inner Socapa station the same condition of affairs existed, as the station was in behind the hill and close down near the water. Cay Smith and Outer Socapa were not so well protected, but were still commanding positions.

The length of channel controlled by these mines reached from the entrance, just off the Morro, up to about midway between Puntilla and Soldados points.

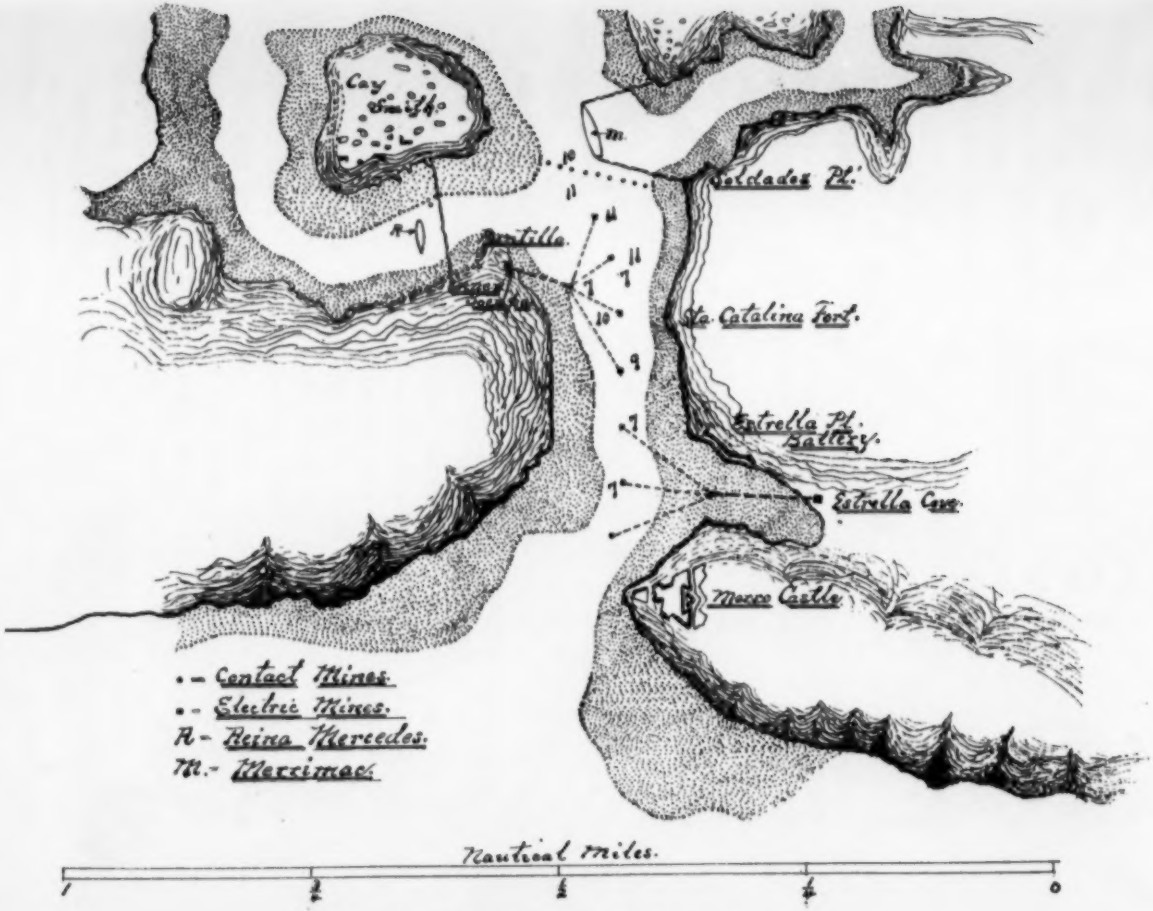
From Cay Smith across the channel, running in about an east southeasterly direction, a line of nine Bustamente, or contact, mines had been planted also, so that any ship attempting to enter the harbor would, of necessity, be compelled to pass over from eight to ten electrical mines, and then across a line of contact mines planted so closely together that she must, if of any considerable beam, surely strike one, and possibly two of them in passing.

The electrical mines were planted on the bottom in from seven to eleven fathoms of water, and the contact mines anchored to float at about eleven feet under the surface.

An effort was made to fire the five electrical mines controlled by the station at Estrella Cove when Hobson made his gallant but unsuccessful attempt to block the channel with the Merrimac, but only two of the five detonated. Further in another mine was fired from the Inner Socapa station, and Hobson reports that it lifted the Merrimac some and probably aided to sink her, as she went down a short distance further in.

After she was sunk the defense of the channel was as follows: A line of three doubtful electrical mines controlled by the Estrella Cove station, four other electrical mines running from a point just off Santa Catalina Fort up the channel, and the nine contact mines before mentioned as running from Cay Smith across to the eastern bank; these last running just under the stern of the Merrimac. In addition to the mines the channel was blocked by two log booms running from the bow and the stern of the Merrimac over to the eastern bank, the logs being secured to each other by five-inch steel hawsers. A similar log boom was also stretched from Puntilla across to Cay Smith. (See Chart.)

The control stations for the electrical mines were small wooden huts covered with branches of trees, and absolutely concealed ex-



SITUATION AFTER SINKING OF MERRIMAC.

cept for a small slit about four inches deep, and just long enough to take in the two ends of the mine field to be operated. These stations contained the most elaborate electrical appliances for testing the circuits and for firing. A large table with testing battery, Wheatstone bridge, and galvanometer was found in each, together with a firing battery, sighting quadrant, and numerous books giving full descriptions of the ships of our Navy, with photographs accompanying. All stations were in telephonic communication with each other. After the surrender it was discovered that on account of the failure of the three mines controlled by the Estrella Cove station, that station was abandoned. Only parts of the testing and firing mechanism were found there, other parts having been destroyed or carried off. The stations on Cay Smith, and Outer Socapa were also abandoned, as the inside station on the Socapa side was considered to be so advantageously located that it, alone, was considered sufficient to control the remaining mines.

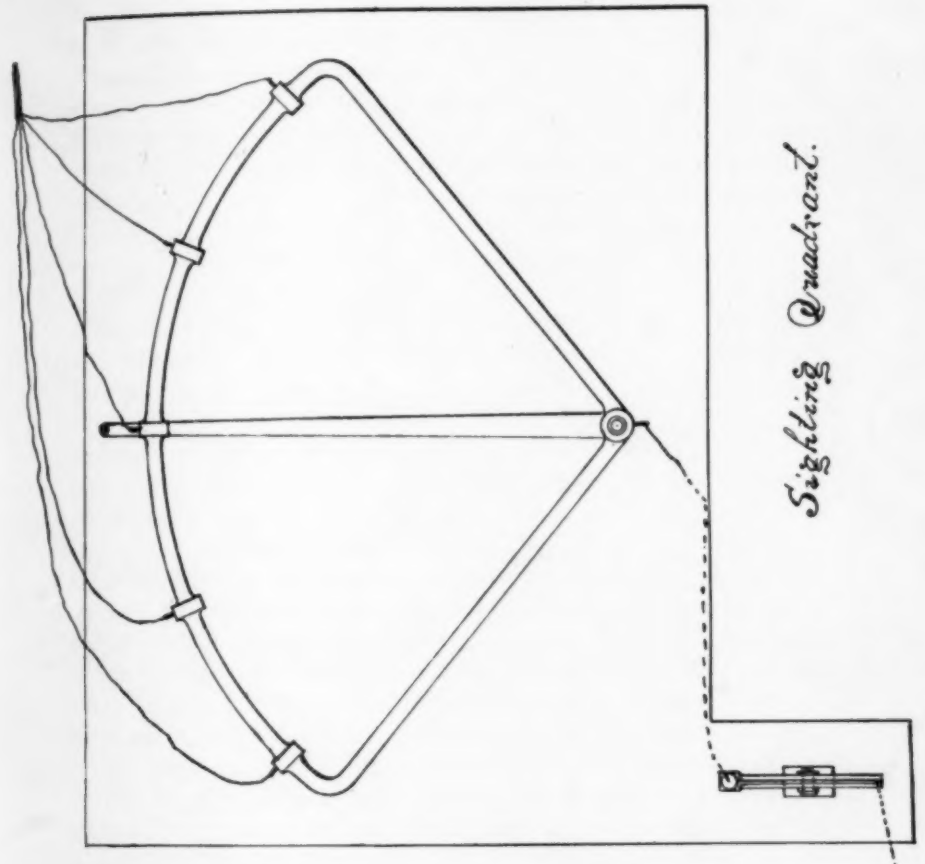
Sighting Quadrant.

The means of determining the proper moment to fire the electrical mines were a sighting bar in connection with a quadrant of a circle, having on it as many contact points as there were mines in the mine field. The sighting bar was pivoted at the center of the circle from which the arc was described, and could be swung around so that its front end could be brought in contact with any one of the contact points on the arc.

The whole arrangement was evidently installed in the control station, and the mines planted on the ranges indicated by the line of sight as given by the bar in its various positions, that is, with its front end on the different contact points of the arc.

The main cable was made up of a number of small well-insulated cables, all bound together and covered with jute braiding for the distance from the control station out to the junction box, and where this cable came into the control station it was made fast, and the separate parts of it were each led to one of the contact points on the arc of the sighting quadrant. These wires, and the contact points were numbered with the same numbers that had been assigned to the mines as they were planted.

Outside of the control station the cable ran out into the water for about one hundred and fifty yards where it led into a junction


Sighting Quadrant.

box, from which branch leads radiated to each of the mines planted. The mine connection of each of these branches was as follows: In the top of the mine was a water-tight stuffing-box, through which the leading wire entered and made fast to one pole of the detonator, the other pole being made fast to the metal of the stuffing-box outside the mine. At the shore end of the cable one pole of the firing battery was placed in contact with the earth, and the other connected to the sighting-bar, the firing-key making a break between the two.

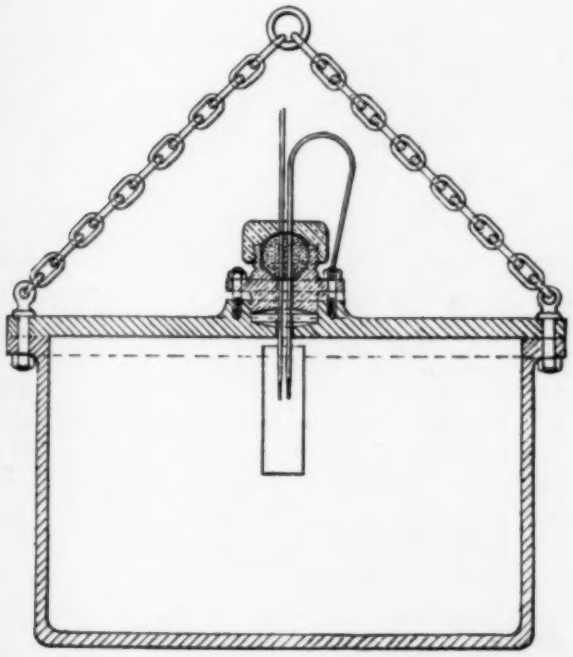
To test any particular mine, place the front end of the sighting-bar on the contact point of the arc corresponding to that mine and, with the testing key and testing battery, in connection with the Wheatstone bridge, and galvanometer, the good or bad qualities of the circuit were established. The arrangement was very simple and at the same time very complete.

To fire a mine under a vessel attempting to run the channel, connect with the firing battery, take the guard off the firing key, and, when the vessel comes on your line of sight, as indicated by the front and rear sights of the bar, press the key.

In order to make the entrance of the harbor safe for the passage of our ships the commander-in-chief, on July 17th, sent a working party in to destroy the electrical mines, and raise the contact mines. Of the four presumably good electrical mines off Inner Socapa, two failed to show continuity of circuit, and, after repeated attempts to detect their faults and to fire them, their positions were located and they were noted "to be raised." The other two were successfully fired, but the column of water thrown up by each was surprisingly small. This may be accounted for, in part, by the great depth in which they were planted.

The two noted "to be raised" were recovered in the following manner without any accident whatever: The "Suwanee," under the command of Lieutenant-Commander Delehanty, was sent in to assist in recovering these mines, as she was fitted with just the sort of anchor gear that was necessary to use in lifting them, and after the chain sling of the mine was once secured, she simply hooked her fish fall in the ring in the end of it, and with her steam winch hoisted the mine up clear of the water. All connections at the control station were broken, simply as a matter of ordinary precaution; the main cable was underrun by a dinghy for about one hundred and fifty yards, where a junction box was found. By

means of a wrench the nuts holding the top on it were taken off, and the box was found to contain a branch lead from the main for each mine planted, each lead having a tag on it corresponding to its number on the contact point on the sighting quadrant. Knowing the numbers of the two mines fired, it was an easy matter to take each of the other two in turn and, leaving the junction box in a boat, underrun its cable until the end of a small chain was



Observation Mine.

found stopped to it at intervals. This chain had a ring in its end, and, after casting it adrift from the cable, the boat was hauled over until it led up and down. The "Suwanee" then steamed up and hooked her fish fall in the ring in the end of the chain, hove the mine up above the water, and a steam launch went alongside and received it. A short chain sling led from each corner of the mine to a ring in the center, and to this ring the hoisting chain made fast. A vessel like the "Suwanee," or a large launch

or tug with good tackles, is absolutely necessary in raising these mines, as they weigh close on to a ton and, if the bottom is soft, sink into the mud for a considerable distance.

The mines recovered were of the following general description: The case was of cast iron, about three-quarters of an inch thick, the top and body being cast separately, and, after the charge of gun-cotton had been placed inside, these were securely bolted together, with a rubber washer between them. The whole thing was in the form of an iron box about thirty-six inches on a side, and about twenty inches deep, and, as stated before, the leading wire entered through a central water-tight stuffing-box. The detonating agents were two fulminate of mercury detonators, each containing about seventy grains, as well as could be judged, connected in parallel, and embedded in the heart of the dry gun-cotton primer.

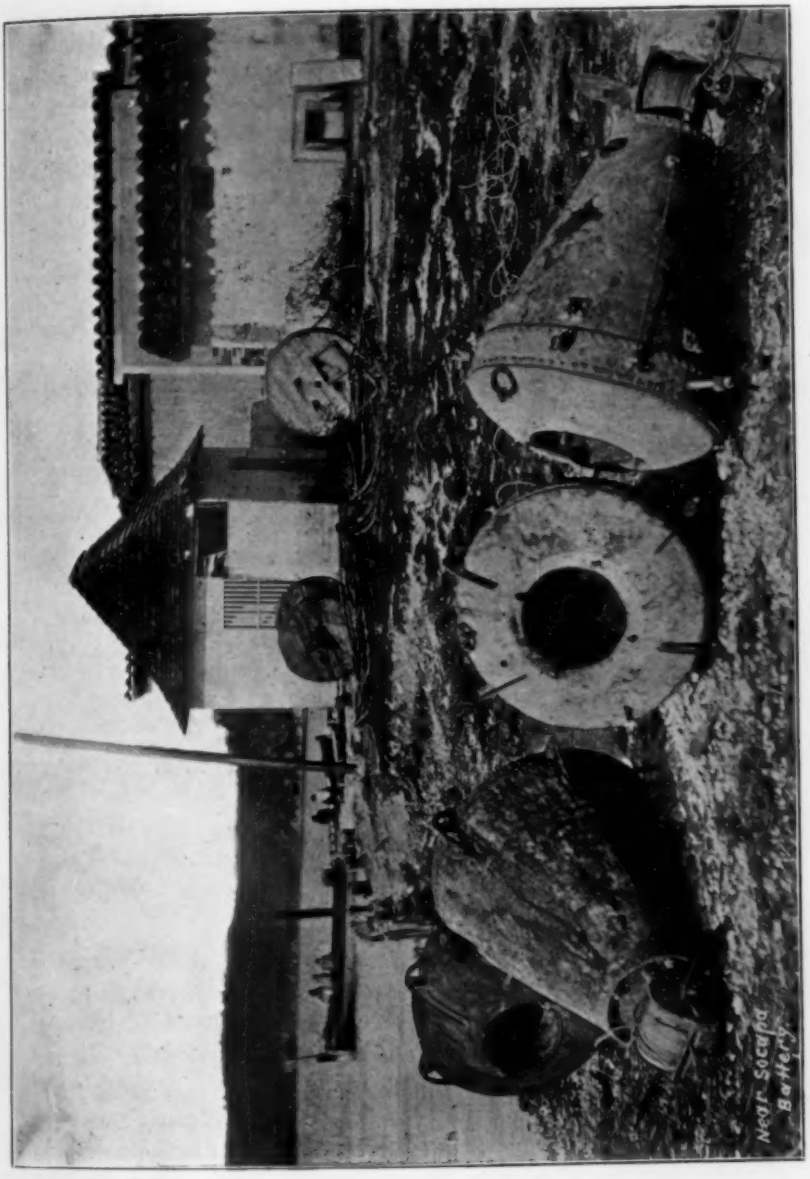
To prevent injury to the connections, from pulls or sudden jerks on the leading wire, a cuckold's neck was turned in it, and made fast to a ring on one of the corners of the mine. As soon as the mine was in the launch the stuffing-box was taken off to permit of an examination being made, and this should always be done if recovering a mine that has failed to fire. If the detonators have fired, well and good, if not, then remove them from the mine at once as a matter of precaution.

The remaining mine off Inner Socapa and those off the Estrella station were recovered in the same general way by the " Suwanee."

Contact Mines.

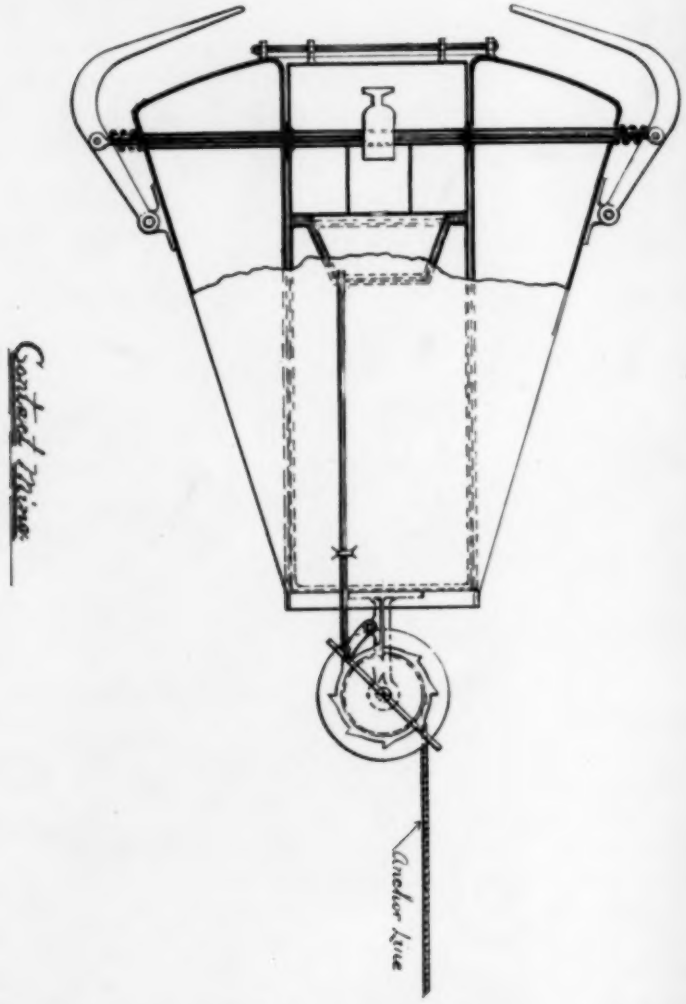
The line of contact mines, running from Cay Smith across to the eastern bank, passed just under the stern of the Merrimac and completely blocked the channel, but on the afternoon of July the second four of these mines were taken up between Cay Smith and the Merrimac, and, on the morning of July third the connections at Inner Socapa were temporarily broken so that the Spanish fleet passed out in perfect safety. After they had passed the mine fields the connections were immediately made again, and the four contact mines planted in their original places. (Chart.)

The operation of recovering these contact mines will probably be better understood after a brief explanation of the method of planting them, and a description of the different parts has been given. The description, as here given, is of the mine as it was



CONTACT MINES AND CABLE REELS.

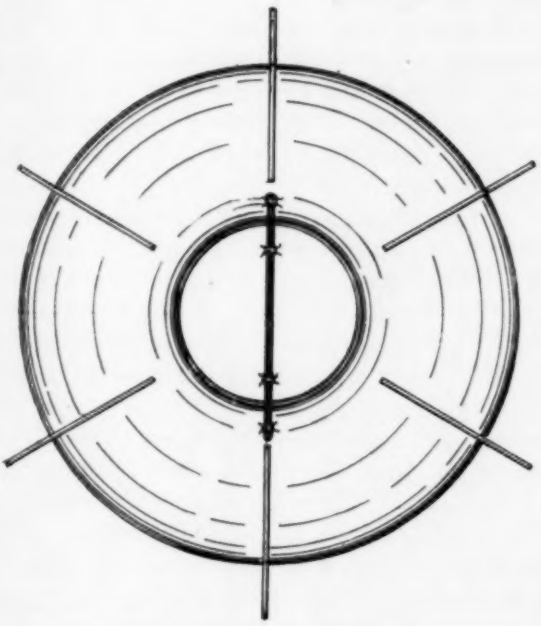
found at Santiago, and may not be exactly technically correct according to the ideas of the inventor, but is correct regarding those recovered. The mine is in the shape of a conical buoy thirty-two inches in diameter at the top, and twelve and one-half



at the bottom, and stands thirty-six inches high. It has a central axial hole in it eleven and three-quarter inches in diameter for the entrance of a cylinder containing the charge of wet gun-

cotton. The bottom of this hole is closed by an iron plate, and on the outside of this plate is secured the frame of a reel which carries about twenty fathoms of wire rope for anchoring the mine. On the barrel of the reel is a toothed wheel, against which a pawl is held by a spring, preventing rotation until the pawl is raised.

On each end of the barrel, outside the frame, is a two-bladed fan, the area of each blade being about sixty square inches. When the pawl is lifted, by a rod running up alongside the mine,



PLAN OF TOP OF CONTACT MINE.

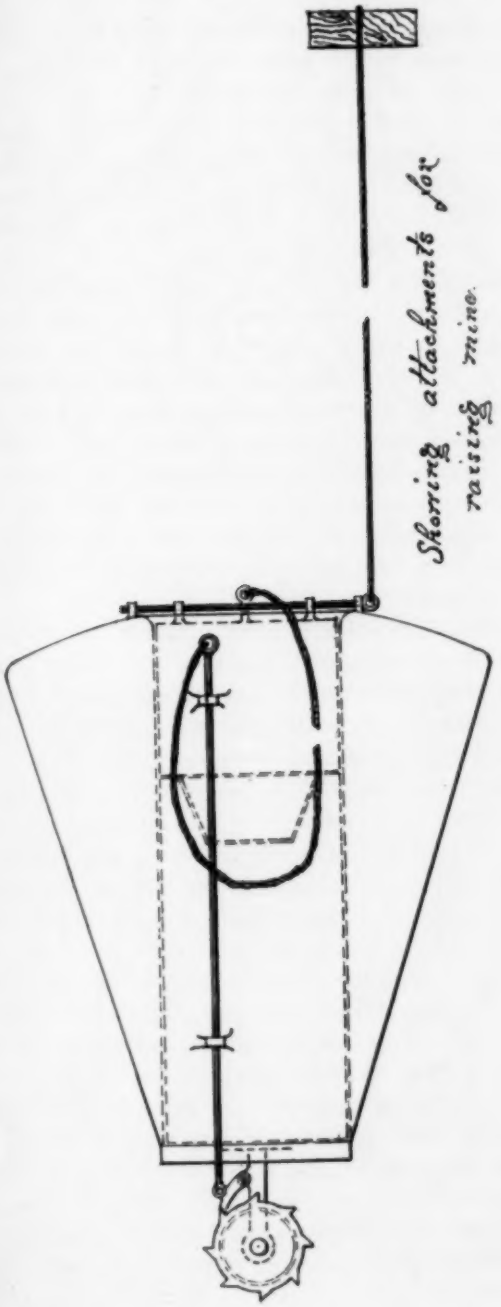
it releases the reel and allows the wire to unwind, and by letting go this rod the spring holds the pawl hard against the toothed wheel and stops the revolution of the reel. The fans are to prevent a too rapid revolution of the reel and a consequent snarling of the anchor wire.

The cylinder which fits in the central hole in the mine contains forty-five kilos. of gun-cotton, and is secured to the bottom plate by four bolts and nuts, but does not reach to the top of the mine by about eight inches.

In the upper end of the cylinder is a conical hole for the reception of a vessel containing the dry primer of gun-cotton. This vessel containing the dry primer is secured against a rubber washer, on the bottom of a small hollow cylindrical buoy, which fits in the upper end of the same axial hole as the large cylinder containing the wet charge.

Inside of the small hollow cylinder are six plungers, spaced at equal distances around the circumference, and converging to the center, where their inner ends rest on a glass tube filled with sulphuric acid; their outer ends being in contact with plungers operated by contact arms on the outside of the mine. The hole in the small buoy where the outer ends of the plungers make contact with those operated by the contact arms is covered with thin sheet lead to make the buoy water-tight, the blow from the contact arm being sufficient to rupture this lead when the mine is struck by a passing vessel.

Around the tube of sulphuric acid is a composition of chlorate of potash and sugar, and a central hole gives communication between this composition and the dry gun-cotton in the conical vessel attached. To the eye, the only substances that could be absolutely determined were the chlorate of potash and the sugar, but this alone will not make, with sulphuric acid, a detonator. Therefore, there must have been some fulminate in combination with these two substances, or in the heart of the dry primer of gun-cotton, to produce a detonating effect. I quote from an opinion of the chemist at the U. S. Torpedo Station, Professor H. F. Brown. "The reaction of sulphuric acid, potassium chlorate and sugar will evolve a large amount of heat and will probably result in an explosion. This explosion will ignite dry gun-cotton, which, consequently, will produce an explosive effect. It is my opinion that this explosion will not be a true detonation unless there intervenes some fulminate of mercury, or other substance whose ignition, like that of the fulminate, amounts practically to a detonation. I should not expect the explosion of a mass of wet gun-cotton which might be adjacent to the dry primer (of gun-cotton)." This opinion is fully substantiated by other authorities, and therefore, although no fulminate appeared to the eye of the observer, it must have been there, or the mine would have been valueless. The detonating agent is, therefore, the material in the buoy and the dry gun-cotton primer.


Showing attachments for raising mine.

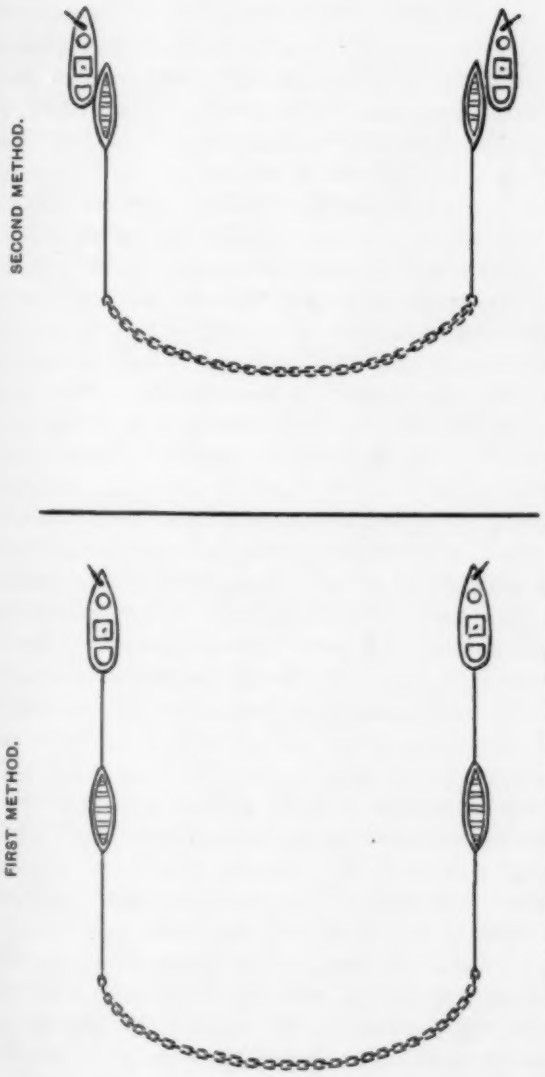
In planting the mines the buoy and dry primer attached are placed in position in the upper end, as a last preparation, and a small rod is run across the top of the mine through lugs, to hold it in place. To one end of this rod a line is made fast, and to the end of the line a small wooden buoy is secured, intended to act as a signal buoy, the length of the line being so judged that the buoy will float a short distance under the water when the mine is planted. The buoy carrying the dry primer has a ring in its top to which a line, from the upper end of the rod operating the pawl on the reel for the anchor wire, is made fast.

The depth of water is known, as is also the depth below the surface it is intended the mine shall float. Having the mine slung, pull up on the rod operating the pawl on the reel and allow the wire to run out to the depth of water, minus the depth below the surface the mine is to float; let go the rod and lower away gently on all. The mine is pulled down under the water and floats at the depth determined upon, while the small wooden buoy, acting as a locating buoy, floats about one foot under the surface. (Sketch.)

The location of the line of contact mines was known, approximately, before the surrender, and this knowledge was verified by the commanding officer of the Spanish gunboat " Alvarado " captured in the harbor. A small boat was used in raising the mines, and the work was carried on in the early morning on account of the light and smoothness of the water, which became rough later on in the forenoon and made it difficult to locate the signal buoys. Once on the range the boat was pulled slowly, with a number of watchers on each side. As soon as one of the small wooden buoys was sighted it was secured, and by pulling on the line steadily the pin running across the top of the mine, holding the cylindrical buoy, with dry primer attached, came out, allowing the latter to rise to the surface quickly. Attached to the ring in the top of the cylindrical buoy is a line which has its lower end made fast to the rod operating the pawl on the reel for the anchor wire. Pull up on this line, lift the pawl, and allow the wire to unreel until the mine comes to the surface.

Lift the cylindrical buoy, with dry primer attached, in the boat, and you have nothing to deal with in the mine but a charge of forty-five kilos. of wet gun-cotton. By pulling up on the rod operating the pawl of the reel, and reaching down with a boat

hook, the bight of the anchor wire was secured and the anchor weighed. A line was then made fast to the mine and it was



METHODS OF DRAGGING FOR SUB-MARINE MINES IN CHANNEL BETWEEN PLAYA DEL ESTE AND CAIMANERA.

towed ashore and hauled up on the beach. The work of recovering eight of these mines required less than a day. This method of recovering contact mines presumes, in the beginning that their

location is fairly well known, as, otherwise, the plan of sweeping for them with two boats must be carried out, as was done by the Marblehead and Dolphin at Guantanamo.

The work of sweeping for the mines at Guantanamo was done at a time when those engaged in it were likely to be subjected to the fire of Spanish riflemen in pits on the left bank of the channel leading up to Caimanera. These pits were covered by the guns of the two ships whose boats were engaged, whilst the pulling boats, in tow of the steam launches, also contained riflemen. The general plan was to sweep with the chain, and line between the boats as indicated in the sketch, and when a mine was secured, place wedges between the body of the mine and the contact arms, as a precautionary measure, until the dry primer could be taken out.

Before leaving the subject of contact mines I wish to say that I discovered an appendage to some of those recovered which I was at loss to understand. This was a small cylindrical bouy, about five inches high, and about eighteen inches in diameter, and was attached by a line to the rod operating the pawl of the reel for the anchor wire. It apparently had been intended to act as a buoy in the original design, but, as found at Santiago, there were holes punched in its sides, as though by a nail, and the result was that instead of acting as a buoy, it had an appreciable weight to it and pulled down on the rod to which it was attached, thus assisting the spring to hold the pawl on the toothed wheel. On some of the mines this was missing, and its office on those where it was found seemed to be of very little importance.

During the latter part of June a plan for countermining the channel leading into Santiago was developed and approved by the commander-in-chief; the officers who had volunteered to carry out the scheme reporting everything ready on the first of July.

The destruction of the fleet, the surrender of the Spanish army, and other incidents made it unnecessary to carry out the plan as developed, but it is simply noted here that the plan was after the accepted ideas of all nations, that is, to explode simultaneously, a number of heavy mines, containing about five hundred pounds of gun-cotton in the mine field. These mines were to have been dropped in succession from a boat, towed by a fast

launch or steamer, and the whole exploded as the last mine reached the bottom. The explosion of a countermine of five hundred pounds of gun-cotton will destroy all mines within a radius of from two to three hundred feet, and the practical application of the proposed plan had every chance of success.

The mine fields were well protected by many rapid-fire and machine guns secreted on the Socapa side of the entrance; the guns and carriages being painted the same color as the earth, and almost entirely covered with brush. Between Puntilla and Cay Smith the Reina Mercedes lay in the cove, protecting the line of contact mines, whilst Punta Gorda battery could fire straight down the harbor. Added to this, the brush on each side of the entrance was thick with concealed riflemen.

Nature had done everything to assist in the protection of the channel, the electrical mines were of the most approved type, and the contact mines, if properly attended to, were dangerous to an enemy. But the very best of tools, if placed in the hands of inexperienced or indifferent workmen, will seldom give good results.

The mines in the entrance were said to have been planted by the officers of Admiral Cervera's fleet, and there were many evidences of the hurry with which they were put down. Lieutenant-Commander Delehanty, who commanded the "Suwanee," and who lifted the observation mines with his ship, says: "None of the mines were recovered intact. The connections were, as a rule, broken, the dry primers drowned out, or the mines partially exploded."

In many places the coverings of the branch cables were chafed off, and some of the strands of the wire bare; the result, no doubt, of paying the cable over the gunwale of the boat used in planting the mines.

The maxim, "that insulation is for the purpose of making electricity go where we want it to go," had evidently never occurred to the officers engaged.

In one electrical mine recovered, there was evidence of a partial explosion, which did not show at the surface of the water. The bottom of the mine was partially blown away, leaving about one-half of it intact, and inside the mine was a large quantity of wet gun-cotton, which rolled out of the hole in the bottom as the mine was lifted and lowered into the launch alongside of the "Suwanee."

In firing exercise spar torpedoes at the torpedo station, the writer has seen it frequently happen that a leak in the top of the case would admit enough water to prevent a detonation, but the case would be ruptured and the torpedo, on recovery, would show that the detonator had gone off, but that the dry primer had become damp or wet. A careful examination of the mines recovered seems to indicate that one of the small, and almost insignificant points connected with the preparation of mines had been entirely ignored. I refer to the method of securing the stuffing-box to the top of the mine. The fact that so many mines had the dry primers drowned out, together with appearance of the stuffing-box, proved that, instead of screwing down gradually on the nuts, securing the stuffing-box to the mine, so that the flange would take equally all around, one side was screwed down tight, and then an attempt was made to screw down the other side. Experience proves that this is not always possible, and I believe that this accounts in a great measure for the failure of most of the mines.

Another point was that the mines seemed to be placed too close to each other. Taking the length of channel to be guarded, and considering the fact that five hundred pound mines may be destroyed, if within three hundred feet of each other, it appears that these were too close, and the detonation of any one of them would, if it did not detonate the others next to it, at least, destroy their electrical connections and render them absolutely useless. This did happen at Estrella, and I believe also at Inner Socapa. The mines that were fired at the Merrimac utterly destroyed the connections of the three that were left at Estrella.

To get the full effect of a mine a ship must naturally be over it, but this can seldom be brought about unless two control stations are occupied. After the Merrimac sank, all but one of the stations at Santiago were abandoned, and therefore it would have been a stroke of extremely good fortune had a mine been detonated at the exact moment when a ship was over it. Experiments have, however, been made to determine the horizontal distance at which an armored vessel would be vitally injured by different charges of gun-cotton in mines, the following being the results:

Mine.	Submergence.	Dist. horizontally.
150 lbs.	10 to 15 feet.	4 feet.
250 lbs.	30 feet.	10 feet.
500 lbs.	60 feet.	15 feet.

This last corresponds nearly with the conditions existing at Santiago, but with the faults in the circuits, and the other attending difficulties, it is scarcely likely that these figures would have been reached.

Conclusion.

Contact mines of the type encountered at Santiago and Caimanera are liable, from the growth of barnacles, to become very much impaired as regards the operation of their different parts, especially the contact arms. This growth forms so rapidly in the warm water of the tropics that in a very short space of time it is sufficient to prevent the arms from driving the plungers in far enough to break the vial containing the sulphuric acid. They therefore require constant attention, and from observation it seems that, to make them effective, they should be raised and cleaned about once in three weeks. The examples of the Texas and Marblehead picking up on their screws mines of this description, are sufficient to illustrate the harmless condition to which they may revert, no matter how good they may be when planted.

Had due care been exercised in planting the electrical mines, and a fair amount of attention paid to the contact mines in Santiago harbor, no ship could have passed the two fields. But the well-known character of the people who planted and attempted to operate them accounts, in a great measure, for the condition in which they were found.

The moral effect of a mined harbor is tremendous, and the question of risking valuable ships is of vital importance. What would have happened to a ship attempting to run the mine field is problematical, but the chances were that she would have been sunk, for, notwithstanding the number of bad mines encountered, enough good ones were left to destroy her.

The electrical mine was perfect in type and design, and had it been properly planted and cared for the protection given by it to the entrance would have been absolute.

The lesson to be learned is evident:—mines cannot be planted hurriedly and carelessly, allowed to remain without attention, and then be expected to give theoretical results.

Officers of Admiral Cervera's fleet stood watch in the control stations at Santiago, and must, naturally, have been alert and attentive to their duties, so that in considering the matter from

all sides the facts which come home to us are these: The theoretical knowledge of those who selected the firing stations, planted the mines, and weighed the question of properly defending the channel was fairly perfect, but in the vital point of a *practical* knowledge of how to prepare and plant these mines they were deficient.

It does not require much of an argument to convince us all that practical education in this particular branch of our profession is what the service needs. The *details*, at times so seemingly insignificant and unimportant, are just the trifles which make success or dismal failure. In a mine defense one cannot admit, for an instant, that there is a chance of failure, for it must be so perfectly installed that it may be counted upon with perfect confidence. This is feasible and possible, and a course of training would, in a short time, make the members of our service masters of the important details, without which knowledge no assured success can be expected in either mine defense or countermining.

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PYRO-COLLODION SMOKELESS POWDER.—PART II.

By PROFESSOR D. MENDELÉEF.

(Translated from the Russian by Lieutenant JOHN B. BERNADOU, U. S. N.)

The "combustion" of a powder is the union of the carbon and hydrogen of the mixture or compound with the oxygen that it contains, and with which it is in association, but not in direct combination. From what has been said already, it is evident that if the powder is to be smokeless and produce the maximum volume of gas, V_{1000}, it must evolve no other gases than carbonic oxide, CO, water vapor, H_2O, and nitrogen, N_2. If hydrogen be evolved, without the formation of the corresponding quantity (equal volume) of carbonic acid, free carbon may result; *i. e.*, the powder will not be wholly smokeless on account of insufficiency of oxygen. If the combustion, as indicated by the equation, reveals carbonic acid or free oxygen (without the corresponding volume of hydrogen), an excess of oxygen is evident, and V_{1000} will not possess its maximum value.

We have, therefore, in the case of a composition or mixture $C_nH_{2m}N_qO_r$, the maximum volume V_{1000} for typical smokeless combustion, corresponding to two conditions: (1) When the content of oxygen, r, is just sufficient to convert the carbon into CO, and the hydrogen into H_2O, *i. e.*, when $r = n + m$; (2) when the content of hydrogen is relatively great, as V_{1000} for H_2O equals 111.1, *i. e.* more than for nitrogen and for carbonic oxide, for which $V_{1000} = \frac{2000}{28} = 71.4$. Moreover, all substances of the composition $C_nH_{2m}N_qO_{n+m}$ will develop volumes between 71.4 and 111.1, if the decomposition products be CO, N_2 and H_2O alone, as is required for rendering V_{1000} a maximum. Our problem becomes, therefore, the comparative examination of those

bodies rich in hydrogen, for which V_{1000} may be greater than for pyro-cellulose (81.5). We must ask: Are there not known substances, or mixtures of substances, rich in hydrogen suitable for smokeless powder? To answer this query, let us examine various definite compounds and mixtures.

Among the carbon compounds a large content of hydrogen is characteristic of methane (marsh gas) CH_4; among the nitrogen compounds, of the ammonium derivatives.

Hydrocarbons of the limiting (saturated) series C_nH_{2n+2}* form nitro-compounds, and may, therefore, produce explosives. To methane itself, CH_4, correspond mono-nitro-methane, $CH_3(NO_2)$; di-nitro-methane, $CH_2(NO_2)_2$; tri-nitro-methane or nitro-form $CH(NO_2)_3$, and tetra-nitro-methane $C(NO_2)_4$. These substances are volatile as well as explosive, but all represent a deficiency or an excess of oxygen. As shown by V. Meyer and Professor Zalinski, the explosive properties of mono-nitro-methane are especially great when it is combined with potassium or sodium to form the metallic salts, CH_2KNO_2, CH_2NaNO_2, which represent, so to speak, first homologues of the salts of nitric acid, since $CH_2NaNO_2 - NaNO_2$ equals the homologous difference CH_2. Experiment shows that this substance belongs to the category of detonating explosives, and is, therefore, unsuitable for use in guns (but suitable for mines).

If the decomposition proceeds without formation of free carbon (although there be but little oxygen) it should be as follows:

$$2CH_3NO_2 = 2CO + 2H_2O + H_2 + N_2.$$

If it be thus, then $V_{1000} = 98.3$, which is very great. But, as has been said, the substance is unfit for use in guns on account of its tendency to detonate. Besides, like other nitro-methanes, it is volatile, and for this reason is further unadapted.

The little known, but doubtlessly explosive di-nitro-methane contains an evident excess of oxygen, developing on combustion, $CO_2 + H_2O + \frac{1}{2}O_2 + N_2$, which corresponds to the relatively small volume $V_{1000} = 66$. It is evident that the excess of nitrogen and of oxygen combined with it in the NO_2, according to the known principle, does not increase but rather diminishes V_{1000}

* See "The Principles of Chemistry," by D. Mendeléef, Ed. 1891, Longmans, Green & Co., London, Vol. I, p. 344. J. B. B.

The same is true for nitroform, $CH(NO_2)_3 = CHN_3O_6$,† and for tetra-nitro-methane, whose discovery is due to the skill of our eminent savant, L. N. Shishkov, both of which contain too much oxygen to develop maximum gas volume. A large value of V_{1000} would be characteristic of mixtures of products of nitration and of hydration (substituting the water radical for hydrogen, $-H + OH$) derived from methane, as

$$4CH_3NO_2 + CH_2N_2O_4 = 5CO + 7H_2O + 3N_2*$$
weight 4.61 + 106 = 5.28 + 7.18 + 3.28 = 350
volume of gases 5.2 + 7.2 + 3.2 = 30
$V_{1000} = 85.$

or

Nitro-methane. Methyl alcohol.

$$4CH_3NO_2 + CH_4O = 5CO + 8H_2O + 2N_2$$
weight 4.77 + 32 = 5.28 + 8.18 + 2.28 = 340
volume = 5.2 + 8.2 + 2.2 = 30
$V_{1000} = 88.2$, etc.

But such mixtures, although possible from the chemical standpoint, are unsuitable for use as powder, as their constituents are in part volatile; and this, apart from the consideration that liquid explosives are liable to detonation, which is more to be dreaded than formation of smoke, as detonation destroys the guns.

Among the closely allied derivatives of methane as a hydrocarbon rich in hydrogen, the development of a large gas volume may be looked for from substances presenting the composition $CN_2H_6O_4$. Such a composition is possessed, for example, by the mixture of a molecule of formic aldehyde (or of one of its numerous polymers) CH_2O, with ammonium nitrate, NH_4NO_3, or the hydroxyl derivative of methylamine (*i. e.* CH_3NH_2 in the form $CH_2(OH)NH_2$) in combination with nitric acid, HNO_3.

† As the typical decomposition of nitroform, we have—

$$4CHN_3O_6 = 4CO_2 + 7O_2 + 2H_2O + 6N_2$$
weight 4.151 = 4.44 + 7.32 + 2.18 + 6.28 = 604
volume 4.2 + 7·2 + 2.2 + 6.2 = 38

* The mixture $7CH_4 + 3C(NO_2)_4$ presents such a composition, etc., but they are all as practically unsuitable for powder as mixtures of mono- and di-nitro methane.

The typical decomposition of such a compound, if realized, would be expressed by the equation:

$$\begin{aligned} CN_2H_6O_4 &= CO + 3H_2O + N_2 \\ \text{weight } 110 &= 28 + 3.18 + 28 = 110 \\ \text{gas volume} &= 2 + 3.2 + 2 = 10 \end{aligned}$$

$$V_{1000} = 90.9.$$

But such a compound either cannot be produced, or else is attained only with great difficulty; or, as a mixture of ammonium nitrate with the polymers of formic aldehyde (*e. g.* glucose, $C_6H_{12}O_6 = 6CH_2O$) develops undesirable qualities, such as hygroscopicity, a characteristic of all mixtures containing ammonium nitrate, and is therefore unsuited for use as smokeless powder.

Hence, after searching through all the possible combinations of the simplest derivatives of methane, we are unable to find among them (as also among substances containing no carbon) any suitable for employment in practice as smokeless powder, although we find compounds developing larger volumes of gas than pyro-collodion, which may prove suitable for use in mines.

If we turn from substances containing one atom of carbon to those with two, three, etc., atoms to the molecule, we shall find, other conditions being the same, smaller values of V_{1000}, the volume decreasing the farther the limit is departed from, as is illustrated in the following table of possible, little volatile, compound ethers of nitric acid* and their hypothetical nitro-compounds, corresponding to the series of alcohols, $C_nH_{2n}(NO_2)_2$.

$3C_2H_4(NO_3)_2 + 2C_2H_6O_2$	$V_{1000} = \frac{50}{580}\ 1000 = 86.2$
$C_3H_6(NO_3)_2$	" $= \frac{14}{166}\ 1000 = 84.3$
$C_4H_8(NO_3)_2 + 4C_4H_7(NO_2)(NO_3)_2$	" $= \frac{99}{1074}\ 1000 = 83.7$
$C_5H_{10}(NO_3)_2 + 4C_5H_9(NO_2)_2(NO_3)_2$	" $= \frac{110}{1330}\ 1000 = 82.7$

etc., etc.

The possible, yet up to the present, hypothetical, nitric ethers of nitro-glucol, although capable of developing large values of

* Considered by themselves these ethers of diatomic limiting (saturated) alcohols $C_nH_{2n}(NO_3)_2$ consume into CO and H_2O only for $n = 3$. For greater values of n there is a deficiency in oxygen; for $n = 2$, an excess. We have chosen them as an example on account of their slight volatility, and because they approximate in composition to nitro-glycerine and nitro-mannite.

V_{1000}, and adaptable on account of their non-volatility, possess no advantages over derivatives of the higher alcohols, such as glycerine and mannite, materials that are readily obtainable, as they are widely disseminated throughout nature. We shall therefore fix our attention upon the latter; first, as they present in their analogues substances extremely rich in hydrogen, capable of producing large values of V_{1000}; second, because they are easily reacted upon by nitric acid, forming the explosive compound ethers, nitro-glycerine, $C_3H_5(NO_3)_3 = C_6H_5N_3O_9$, and nitro-mannite, $C_6H_8(NO_2)_6O_6 = C_6H_8N_6O_{18}$. Both of these nitro-derivatives are easily prepared. The former was first employed as an explosive by the renowned Russian chemist N. N. Zinin, at the time of the Crimean war, and subsequently by V. F. Petrushevski in the 'sixties, before the discovery and very general employment of Nobel's dynamite and other nitro-glycerine preparations; the cause of their general use being the ease with which the base material—glycerine—was obtainable in nature, while the reaction with nitric acid (admixed with sulphuric) was easily effected; *i. e.*, the manufacturing process was a simple one.

Nitro-mannite, isolated and investigated by N. N. Sokolov, professor at the Medico-Chirurgical Academy, is also easily prepared, but not in its lower degrees of nitration. This circumstance is important for the reason that the readily manufactured nitro-glycerine and nitro-mannite are not themselves available for use in guns, although very well adapted for detonating effects. They correspond, moreover, to relatively small values of V_{1000}, as they contain an excess of oxygen:

$C_3H_5(NO_3)_3$ affords $V_{1000} = 63.9$
$C_6H_8(NO_3)_6$ " $V_{1000} = 61.9$.

But as these substances contain an excess of oxygen, they may be admixed with others containing a deficiency thereof, which they consume, evolving carbonic oxide, and developing relatively large volumes, V_{1000}; while by admixture with such substances low in oxygen, or not containing it, their detonating qualities may be caused to diminish, or made to vanish, as in dynamite, by combination with an inert base (tripoli, magnesia, etc.), whereby the tendency of nitro-glycerine to detonation through shock is diminished. In this manner, by admixture with a combustible substance, nitro-glycerine powders are formed. If we take Cor-

dite as an example, we find that on account of its excess of oxygen it produces a relatively small gas volume; we may, therefore, select a mixture of nitro-glycerine and collodion (assumed as $(C_6H_8(NO_2)_2O_5)$ such as Ballistite and determine for it V_{1000} on the assumption that it shall develop only CO, H_2O and N_2.

$$2C_3H_5N_3O_9 + 7C_6H_8N_2O_9 = 48CO + 33H_2O + 10N_2$$
$$\text{weight } 2.227 + 7.252 = 48.28 + 33.18 + 10.28 = 2218$$
$$\text{volume of gases} = 48.2 + 33.2 + 10.2 = 182$$
$$V_{1000} = 82.1 .$$

Therefore, if nitro-glycerine powders contain only the quantity of nitro-glycerine necessary to produce H_2O and CO, then the volume of gases evolved by them is almost the same as that developed by pyro-collodion. It is evident, then, that neither nitro-glycerine, nor its mixtures when employed as smokeless powder, evolve volumes of gases greater than pyro-collodion, and that admixture with other substances, of whatever kind they may be, although homogeneous from the mechanical standpoint, are still far less homogeneous than any single substance, and that it is useless to seek for nitro-glycerine powders capable of exceeding pyro-collodion powders in point of magnitude of V_{1000}, apart from other considerations. This applies also to nitro-mannite, the source of preparation of which is far less common than glycerine, and to many of the hydrocarbons analogous thereto, as glucose, starch, cellulose, etc. If all of the six atoms of carbon in mannite are in the same combination as in the limiting (saturated) alcohols:

$$C_6H_{14}O_6 =$$
$$CH_2(OH)\ CH(OH)\ CH(OH)\ CH(OH)\ CH(OH)\ CH_2(OH),$$

then in glucose, $C_6H_{12}O_6$, one atom of carbon should be combined as in aldehyde,

$$C_6H_{12}O_6 =$$
$$COH\ CH(OH)\ CH(OH)\ CH(OH)\ CH(OH)\ CH_2(OH),$$

and, therefore, if mannite represents a hexa-nitrated product (compound ether as derived from an alcohol) glucose represents only a penta-nitrate. Materials such as cellulose, starch and the like, of composition $C_6H_{10}O_5$, may be regarded as the pre-

ceding alcohols,—anhydrous, arranged as follows with reference to the di-alcoholic groups,

$$C_6H_{10}O_6 = COH\ CH(OH)\ CH(OH)\ CH(OH)\underbrace{CH\ CH_2}_{O},$$

whereby it appears that there are only three complete alcohol groups remaining out of the six in mannite. Therefore, in the latter case, we should expect to find only tri-nitrated products, which is actually what occurs. If such a scheme throws light on the matter from one standpoint (as relates to the number of hydroxyl radicals giving rise to nitric ethers) it illuminates it obliquely from another, which is of considerable importance to us. In all aldehydes, beginning with the formic and acetic, a tendency to polymerization is to be noted, due, doubtlessly, to the property of aldehydes of entering into various combinations (with H_2, O, $NaHSO_3$, etc.); whence the composition $C_6H_{10}O_5$, containing an aldehyde grouping, should also possess this property, as far as relates thereto. We may, therefore, safely assume that the molecular composition of cellulose, judging from its properties, is polymerized, *i. e.* it is of the form $C_{6n}H_{10n}O_{5n}$, where n is probably very great. If we assume $n = 5$, the cellulose becomes of composition $C_{30}H_{50}O_{25}$, and, for the highest degree of nitration, $C_{30}H_{35}(NO_2)_{15}O_{25}$. But pyro-cellulose has a composition $C_{30}H_{38}(NO_2)_{12}O_{25}$; therefore, the number of independent nitro-celluloses (nitric ethers) may be very large.

This is very important in the conception that the nitration of cellulose may be carried up to any desired degree, and for known concentrations a mixture of nitric and sulphuric acid neither dissolves nor reacts upon a product of nitration. Again, cellulose is the most widely disseminated in nature of all the hydrocarbons possessing the composition $C_6H_{10}O_5$, constituting the tissues of all plants and prepared from time immemorial in great masses as cotton, flax, paper, etc., while its products of nitration present an unalterable material suitable for conversion into smokeless powder. This side of the matter needs no further elucidation, but it must be remembered that before the development of pyro-collodion it was stated that the higher the nitration of the cellulose the higher the explosive produced, and that in manufacturing powder from highly explosive nitro-cellulose (of composition about $C_{30}H_{36}(NO_2)_{14}O_{25}$, collodion (of composition

about $C_{30}H_{40}(NO_2)_{10}O_{25}$) was added, for the reason that higher nitro-celluloses in the form of filaments or dust were easily detonated (whence their employment for mines), while the latter property was reduced or caused a disappearance after gelatinization, of which collodion was easily susceptible and for which purpose it was added. The introduction of pyro-collodion changed existing views upon the subject, showing that maximum force for nitro-cellulose was not to be sought from the highest degrees of nitration (*i. e.* for maximum content of nitrogen and oxygen), but that it obtained for that mean degree of nitration present in pyro-collodion. For the latter material $V_{1000} = 81.5$; while for nitro-cellulose of maximum nitration, $C_6H_7(NO_2)_3O_5$, $V_{1000} = 74.1$. The above represents only one side of the theoretical investigation of materials suitable for smokeless powder; but other considerations are also in accord, as will be shown later; and we have, therefore, gone considerably into detail, the more urgently since it has been necessary to struggle with prejudice, harmful to success in such a new field as that of smokeless powders.

Among the possible materials proposed, apart from mixtures of such different bodies as ammonium nitrate and various organic substances (such mixtures were rejected in practice), must be considered the nitro-compounds corresponding to benzol and its derivatives, naphthalin, etc., as coal-tar constitutes an abundant source for their production in large quantities, and they are easily nitrated. From the class of the so-called "aromatic compounds" derived from benzol, C_6H_6, it is useless to expect smokeless explosives developing large volumes of V_{1000}, although many are high explosives, beginning with Melinite or picric acid, $C_6H_2(NO_2)_3OH$, which constitutes a powerful material, although far from the best, for torpedoes and explosive shells; and since some of the first smokeless powders were mixtures containing picric acid. The cause of the small gas volumes V_{1000} developed by the aromatic compounds is due to their composition, as they are all low in hydrogen. This view may be illustrated by a few examples.

To benzol correspond bodies whose general composition may be expressed by the formula $C_6H_{6-a}(NO_2)_a$. If a equal 1, 2 or 3 (these substances are known and easily obtained), the oxygen content is insufficient to consume the carbon into CO and the hydrogen into H_2O, although explosion occurs with the formation of carbon (smoke, soot) and of hydrocarbons.

Total smokelessness could be realized from mixtures of highly nitrated products, as

$$4C_6H_2(NO_2)_4 + C_6H_4(NO_2)_2 = 30CO + 6H_2O + 9N_2$$
weight: $4.258 + 168 = 30.28 + 6.18 + 9.28 = 1200$
volume of gases $= 30.2 + 6.2 + 9.2 = 90$
$V_{1000} = 75$.

If, instead of such non-existing highly nitrated benzols, pyroxylene be employed (as in the American smokeless powders of Munroe and other inventors), a gas volume approaching that developed by pyro-collodion is realized.

$$6C_6H_5NO_2 + 26C_6H_7N_3O_{11} = 192CO + 106H_2O + 42N_2$$
weight $6.123 + 26.297 = 192.28 + 106.18 + 42.28 = 8460$
volume of gases $= 192.2 + 106.2 + 42.2 = 680$
weight, $V_{1000} = 80.4$.

The matter assumes a different aspect if ammonium nitrate NH_4NO_3 be employed for converting the carbon and hydrogen of nitro-benzol into CO and H_2O. This substance contains a large amount of hydrogen for a relatively small content of oxygen (but for this result a large amount of NH_4NO_3 must enter into the mixture), and greatly increases the volume of gas developed, as is evident from the following:

$$2C_6H_5NO_2 + 13NH_4NO_3 = 12CO + 31H_2O + 14N_2$$
weight $2.123 + 13.80 = 12.28 + 31.18 + 14.28 = 1286$
volume of gases $= 12.2 + 31.2 + 14.2 = 114$
$V_{1000} = 88.7$.

But mixtures of this salt must always be avoided if a satisfactory smokeless powder is to be produced, as it is soluble in water as well as hygroscopic, and produces with viscous oily materials only coarse mechanical mixtures.

Similar results are to be obtained from other aromatic substances, and we may refer by way of example to mixtures of pyroxylene with picric acid, $C_6H_2(NO_2)_3OH$, and nitro-naphthalin, $C_{10}H_7(NO_2)$, as such compounds have been recently experimented with (but abandoned in practice) as smokeless powders. Among other disadvantages, they develop smaller gas volumes, V_{1000}, than pyro-collodion, on account of their relatively small content of hydrogen.

After an examination in the above manner of the composition and properties of all possible material capable of employment as smokeless powders, we arrive at the following deductions in relation to the volume of gases (measured at given temperature and pressure), V_{1000}, developed by their combustion:

1. Only substances containing nitrogen, carbon, hydrogen and oxygen are capable of entire conversion, as required for smokeless powders, into gases that do not react upon gun-metals. Hence all other explosive substances (*e. g.* fulminate of mercury, chloride of nitrogen, etc.) containing haloids, metals, phosphorus, etc., are unsuitable for use in gunpowders.

2. When the combustion of carbon results in the formation of carbonic acid gas, CO_2, a less volume of gas is formed than when carbonic oxide, CO, is the resultant product, and as the former requires more oxygen than the latter, the increase of oxygen or nitrogen (if, as is usually the case, the oxygen enters into combination with the aid of the elements of nitric acid) is injurious, instead of useful, although there exists full conversion into gases as is required for smokeless powder.

3. The greater the quantity of hydrogen in the powder, other conditions being equal, the greater the gas volume, V_{1000}, corresponding to the combustion of the powder, and, therefore, substances derived from the limiting (saturated) series of hydrocarbons are more suitable than bodies of the "aromatic" series for smokeless powders.

4. Not any of those explosive materials not containing carbon (as N_3H, NH_4NO_2), that evolve large volumes of gas V_{1000} and decompose upon ignition, are such that will not detonate, *i. e.* evolve their gases so rapidly that they crush the walls of guns; whence it is useless to consider them as materials adaptable for conversion into smokeless powders.

5. Some of the materials containing but little carbon and much hydrogen may prove suitable for use as powders or powder mixtures, evolving large volumes of gas upon combustion; but, so far as known, they are either volatile or liable to decompose spontaneously and detonate, or else they are prepared with difficulty from mixtures not widely disseminated, so that at present it is useless to look for materials for smokeless powder from among them.

6. Nitro-glycerine itself develops but a small gas volume

($V_{1000} = 63.9$) as it contains an excess of oxygen. It may be employed in mixtures to form smokeless powder, and its mixtures with nitro-cellulose, such as Cordite and Ballistite, which are practically homogeneous from a physical standpoint, develop gas volumes V_{1000}, a little less than that evolved by pyro-collodion (although such mixtures erode guns, as already stated).

7. Cellulose, $C_{6n}H_{10n}O_{5n}$, is a substance widely disseminated in nature and of general industrial employment; by its non-volatility, insolubility, durability, etc., and by the readiness with which it is nitrated (as it contains much hydrogen), it constitutes a superior base for smokeless powders.

8. Among all the forms of nitro-cellulose capable of smokeless combustion, the maximum gas volume V_{1000} corresponds to $C_{30}H_{38}N_{12}O_{49}$ (= 12.44 per cent. nitrogen), which is pyro-collodion, for which $V_{1000} = 81.5$, and which is capable of complete gelatinization in a mixture of ether and alcohol, in which form it is completely free from any tendency to detonate. In the first place, it is the most suitable of all the nitro-celluloses; in the second, it is the most rational and readily obtainable form of smokeless powder, destined to supplant not only other smokeless powders, but also to replace, by reason of its greater homogeneity and its combination of qualities, other pyroxylene powders.

Pyroxylene powder is a mixture of nitro-celluloses, of higher nitration, such as $C_6H_7(NO_2)_3O_5$ and of lower, as $C_6H_8(NO_2)_2O_5$; pyro-collodion is a definite homogeneous single form of nitro-cellulose. By changing the proportional relation of contents of the high, or insoluble, and low, or soluble nitro-cellulose, it is evidently possible to make the pyroxylene approach the pyro-collodion powders; but (as has been shown in recent years, especially in cannon powders) the limit of improvement of these forms always falls short of pyro-collodion. The latter is homogeneous and unchangeable, while pyroxylene powders vary according to their composition. However, from its origin it is in no wise different from the perfected powder of Vieille (although considerably different from the original form thereof) presenting instead of a mixture, from the chemical and mechanical standpoint, a homogeneous limiting mass of the composition $C_{30}H_{38}N_{12}O_{49}$, which is required in order that the powder may create upon combustion the maximum volume of vapor and gases. It is certain that henceforth pyroxylene powder will continue to approximate

to the pyro-collodion until the two become identical. In brief, pyro-collodion represents the Russian limit of modification and improvement of the French pyroxylene powders, the development of which marked an epoch in ordnance progress, but which has not hitherto presented an invariable and constant relation of the elements entering into its composition. In this light pyro-collodion powder may well be styled Franco-Russian. Begun in France, it has been completed in Russia.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

DISEASES OF ELECTRICAL INSTALLATION IN THE NAVY.

THEIR CAUSES AND REMEDIES.

By LIEUTENANT B. T. WALLING, U. S. N.

(From lectures delivered before the U. S. Naval War College—*Concluded from No. 86.*)

Fig. 31 is a correction to Fig. 17 which inadvertence in transmission is made to represent a C. type engine. Fig. 17 properly represents a B. type engine and all references heretofore made to that figure should be referred to Fig. 31.

FIXTURES.

The contemplated changes in design are merely those in smaller details for better degree of water-tightness; the general idea of the devices seems to be in the main satisfactory.

Portable.—The most troublesome fixture, in so far as continuity of service is concerned, is the very convenient and much used portable. The chief disadvantage of Portable No. 5, Fig. 32, is its want of water-tightness, for which a globe seems to be the only solution, and which has been introduced in the especial type, Portable A, shown in Fig. 33. A third type, Portable B, shown in Fig. 34, is now issued for coal-bunker use.

Portable A is necessarily heavy and the globe can easily be broken. No. 5 is to be preferred for uses where water-tightness is not desired.

Presuming a portable to be properly wired up (a job requiring much patience and a skillful hand) the lack of water-tightness, particularly for fire-room and double bottom use, where the fixture receives its hardest usage and is most exposed to mois-

ture, occasions many of the grounds that cause the flickering of the ground-detector lights and give rise to the remark, so often heard in dynamo rooms, that the ground-detector will generally announce the turning on of a fire-room portable.

In practice the lack of water-tightness becomes but one of the evils which cause the grounds; the others are:

1. The construction of the double conductor used.

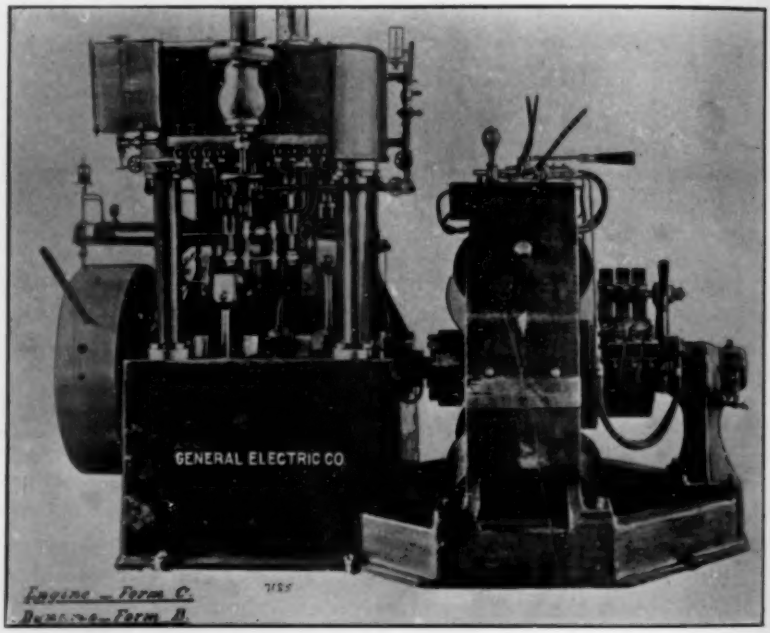

FIG. 31.

2. Mechanical injury by those using the portable.

The concentric double conductor (hemp portable) heretofore in use has never assured good or efficient wiring; in fact, its greater flexibility may be a doubtful advantage over its difficult manipulation in overcoming grounds. Each strand was composed of 28 number 20 B. W. G. wires, so small and brittle that they easily fringed out in twisting, and, as one strand must be bared in order to wire up the socket, the fringe easily grounded to the metal base. At the plug end of the conductor another

difficulty presented itself in that the wires, when twisted, were so bulky as to prevent the contact screws from setting home and to the extent that the screw head had to be filed down (in order to enter the collar) and became too weak for good service. This is a common fault with this work when done on board ship.

The latest construction has seven No. 25 B. & S. G. wires laid concentrically, which overcomes the fringing tendency; the excessive bulk of the twisted strands (under the contact screws of the plug) can be eliminated by splitting the strand into two parts and laying the parts flat under the screw-head. This

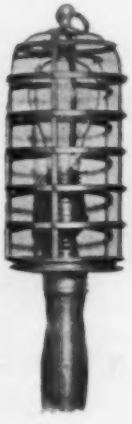

FIG. 32.

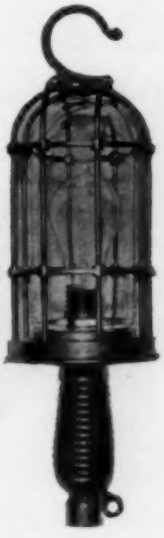

FIG. 33.

method is much lost sight of when wiring is done on ship-board and is an inflexible rule for proper workmanship.

Our original twin conductor, consisting of two insulated wires protected by braiding, is probably the best solution of the construction of double conductor, plain; it is less flexible as compared with other designs, but it is easy of manipulation, efficient and cheap.

Mechanical injury by those who are using the portable manifests itself in the wholesale breakage of attachment plugs, amounting in one ship to sixty, in a period of four months.

Inserting a plug into its receptacle demands no skill; it simply requires that the plug be carefully pushed into place with one hand and secured by screwing on the collar with the other hand. As practiced, attempt is made to do both operations with the same hand, the rubber plug is twisted and broken, which short-circuits the lamp or occasions grounding to the receptacle box. It has been suggested that much of the breakage mentioned can be avoided by constructing the plug of oak or other hard wood, a suggestion that is to be recommended and should be adopted. Breakage of attachment plug occurs as well wherever they are used for receptacles, but that of portable use is much in excess.

FIG. 34.

A peculiar instance of the use of attachment plugs was brought to notice in a complaint that those furnished the ship would not operate. It was found that the portables had been wired up to *25-ampere plugs* instead of to 5-ampere plugs.

Referring to Fig. 35, it will be seen that the 25-ampere plug is not double pole and, therefore, it short-circuits the lamp when inserted in a 5-ampere receptacle. The lamp cannot burn and an unnecessary extra load to the dynamo is the result of the thoughtless error.

Ceiling Fixtures.—This type of fixture has its main fault in the scaling of the reflecting surface due to the heat of the lamp. Properly this reflecting surface should be a hard enamel on iron, a construction now quite common.

The reflecting surfaces can be kept in efficient order by the occasional use of enamel paint; this paint is cheap, is common commercially and serves another good purpose as a means of a touching up the outside of the rings of silver fixtures when the plating becomes worn.

Bronze rings, junction boxes, switches, etc., are best kept in neat order by the use of black varnish or asphaltum applied at least once a quarter.

Wires to ceiling fixture sockets should never be led through holes bored in the side of the socket as such practice vitiates the water-tightness.

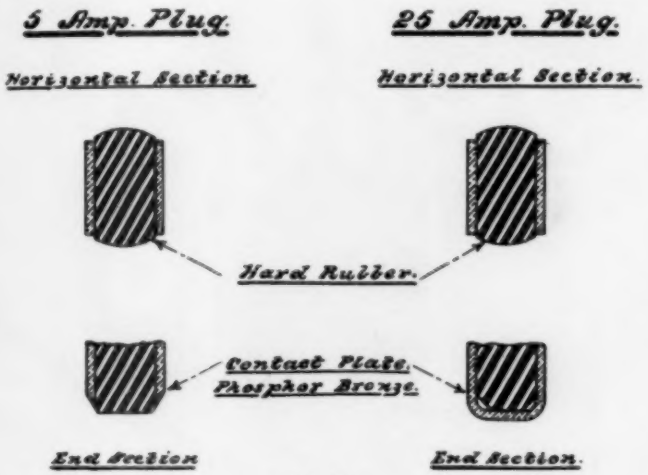

FIG. 35.

To insure against the admission of moisture care should be taken that the globes are always screwed firmly against their rubber rings. Frequent cases of corrosion of sockets and contacts occur from neglect of this injunction.

Steam-tight Fixture.—The usual difficulty with this fixture is abnormal breakage of globes due to want of provision of guards in exposed locations. The guarded fixture should always be installed where there is the slightest liability to accident or mechanical injury and is practically imperative in boiler and machinery spaces, their connections, and where tools are to be used. The nature of the use of this fixture makes it an especial case of a tight fit of globes against their rubber rings.

Diving Lamp.—This device has usually met with many difficulties. It is particularly exposed to short circuit from breaking of insulation due to the rough handling by a diver who is otherwise much encumbered.

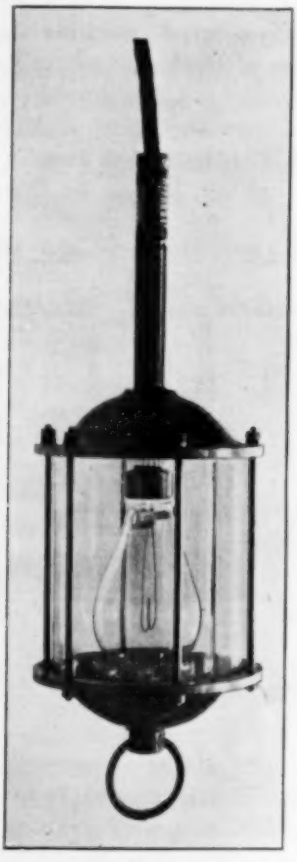

FIG. 36.

Fig. 36 shows the present fixture with its incandescent lamp of 150 c. p., and also a spring device which has proved successful in preventing nips, which cause the breakage of insulation at the handle of the lamp, at which point the ground or short circuit occurs.

Bulkhead Bunker.—The two difficulties met with are breaking of the glass and want of water-tightness, the latter usually the

result of the former. The difficulty has never been overcome and can probably only be remedied by a new design. The expedient of securing the globe flange with felt and red lead does not make a water-tight joint as the mass hardens and breaks away from the glass. It seems necessary that the globes should be jointed with rubber rings and to accomplish this the flanges must be truly parallel, a matter almost impracticable with glass-makers; grinding the flanges to parallelism breaks the skin of the glass and introduces a plane of weakness just as breaking the skin of a rolled shaft weakens the shaft at that point. The present design

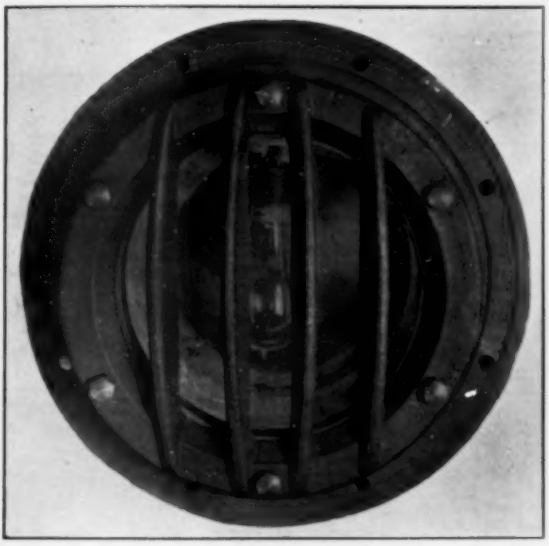

FIG. 37.

of globe is advantageous on account of the better dispersion of light.

The better distribution of these bunker globes will in the future remove many troubles of bad lighting that have been complained of by the engineers, especially near the doors leading into the fire-room. Portable B will afford much assistance in this respect.

A new type of fixture, shown in Fig. 37, is installed in the Chicago.

Desk Light.—The present pattern seems to fulfill a majority of

the needed requirements. Present specifications require that cup hooks and a new hook of square section shall be provided in convenient places for hanging the light.

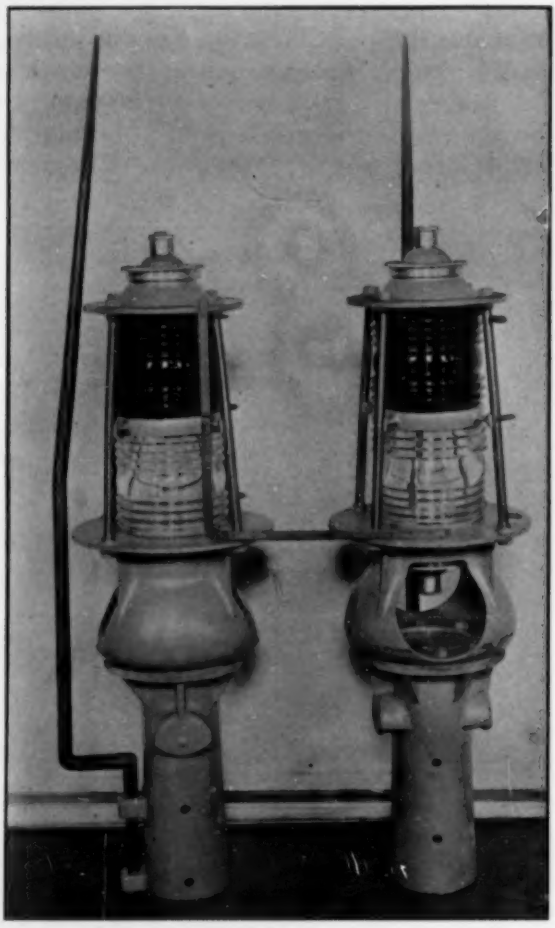

FIG. 38.—DOUBLE TRUCK LIGHT.

Truck Light.—Fig. 38 shows the present type in use; the masts to be provided are mentioned in the specifications.

This light is a continual source of repair, not in the fixture itself but in the wiring on the mast. The source of the difficulty

can commonly be found in the connections on the topmast near the light, or in those of the receptacle box placed at the bibbs or near the top.

The leads for truck lights should in all cases be double conductor, plain wire led in conduit to the receptacle box. The topmast lead should be in a score in the back of the mast (especially in those ships in which the topmasts do not house) and

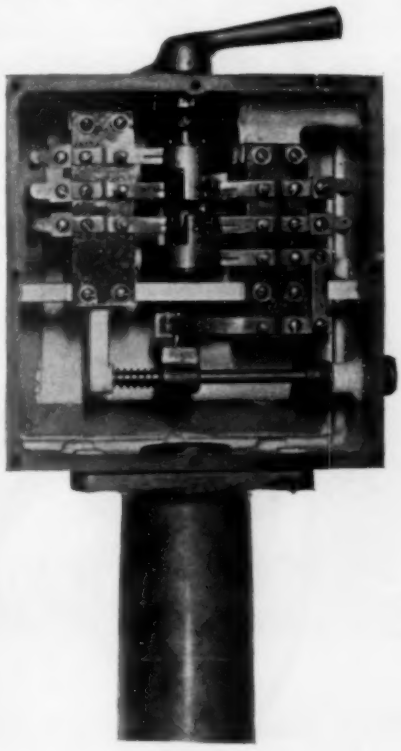

FIG. 39.

should be carefully covered in. Objection has been made to scoring topmasts on account of the tendency to weaken the mast, but the objection cannot be considered to be well taken in this connection and would certainly alleviate, if it did not remove, the great majority of the difficulties met with. The wiring is otherwise much exposed to weather.

One of the recent improvements in truck light manipulation

has been the introduction of a controller, located on the bridge, by which both the lights of both masts can be operated from the same pedestal by a single lever. It is shown in Fig. 39. It is practically free from the effects of weather on the connections.

Mechanical Engine Room Telegraph. (Annunciator.)—The method of lighting with oil has been unsatisfactory, and many of the fixtures have recently been improved by leading wires to a receptacle on the pedestal and using an electric light which is designed to fit in the slide provided for the lamp. The design is shown in Fig. 40. The lamp used in this fixture is 5 c. p. at 80 volts.

FIG. 40.

Electroliers.—These fixtures have been provided as a relief to the inefficient lighting over ward room tables; a two-light fore-and-aft branch will be found most satisfactory. Drop lights should ordinarily be desk lights; a two-branch bracket will prove a satisfactory reading light.

Battle Lanterns and Deck Lanterns.—The difficulties usually complained of are found at the plug (as explained under portable) and grounds in the exposed receptacle boxes; the fixtures themselves rarely give trouble with reasonable wear.

Fig. 41 shows the present type of battle lantern on its bracket with the hook for the bight of the conductor.

Search Lights.—The first fault of search lights resides in the use of an inclined lamp.

1. From the weight which is required to be lifted by the "striking arc" (series) magnet in excess of its real function of merely separating the carbons. Any mechanical resistance which is introduced, such as friction, dirt from carbons, etc., interferes

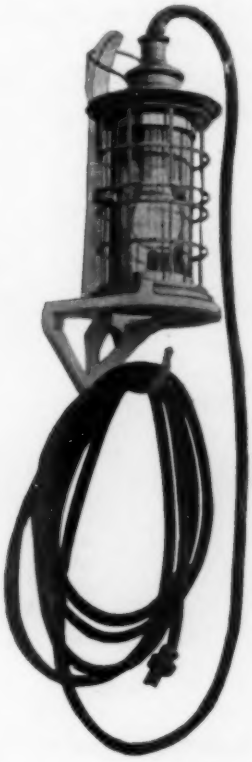

FIG. 41.

with successful working; the series magnet is unable to separate the carbons, and a prolonged short circuit with small resistance ensues which overloads the dynamo or fuses the main contacts in the pedestal.

2. The fragile lava insulators continually break, short-circuiting the system. While lava is, perhaps, the cheapest and most efficient method of insulation, the numerous types of washers

necessary to the device continually break and are very troublesome to replace, proving a continual source of annoyance.

3. Fusing of the contact plungers of the pedestal whose office is to make connection from the contact rings of the base to the main contacts for the lamp. When this fusing takes place the pedestal becomes locked and cannot revolve. It is commonly caused by the non-separation of the carbons, either from failure of operation of the mechanism or the adherence of the carbons due to the formation of a mushroom on the negative carbon.

The mushroom appears as a small protuberance on the end of

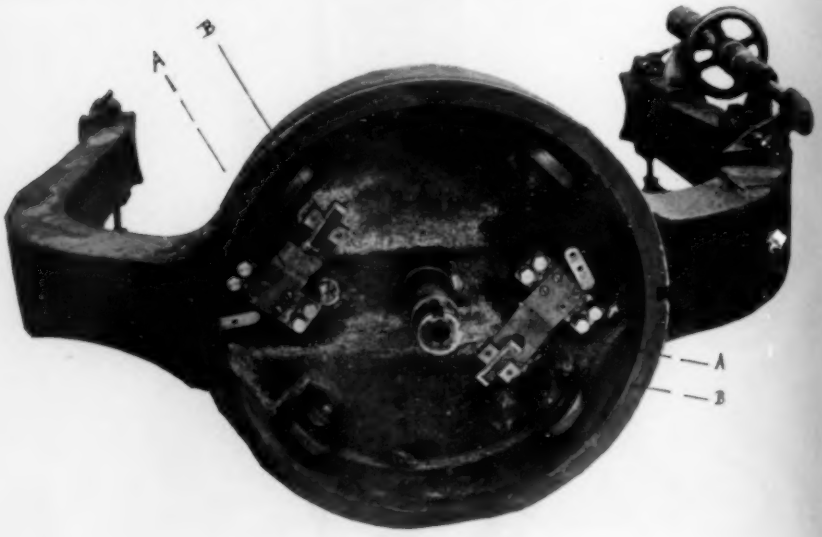

FIG. 42.

the carbon and is of a pasty consistency. It can readily be removed by the edge of a file or screwdriver and ordinary attention to the working of the lamp should guard against its formation. In most cases the carbons will adhere if a mushroom forms.

The remedy for the fusion of plungers is shown in Fig. 42, a method of repair that has been successfully practiced in several ships. It consists of a phosphor bronze spring, *A*, in which are set brass blocks or brushes, *B*, the springs being secured to micanite insulators. The brushes take against the contact rings in the base of the pedestal and afford a much larger contact surface.

In the latest projectors the contact rings are made a part of the *pedestal*, the plungers being placed in the base; this relieves, though it does not obviate, the difficulty.

The inclined lamp has been replaced by a horizontal type, constructed somewhat on the Schuckert principle. Figs. 43 and 44 show two views of the latest type for 30-inch, type H, projectors. The design is similar for all projector sizes. Newer designs show slight changes in mechanical construction.

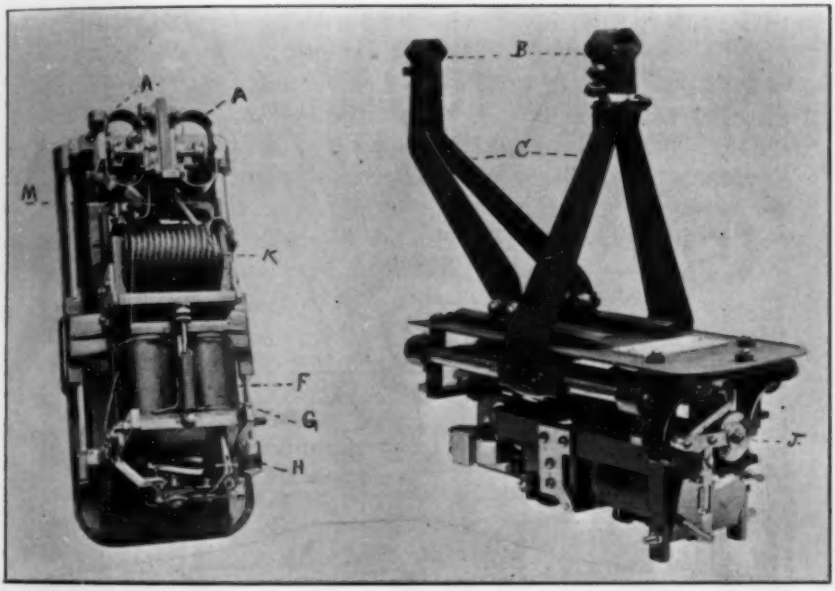

FIG. 43. FIG. 44.

The springs, *A*, take current from leads to the contact rings of the pedestal (to the plungers in older types), the path of the current being shown in Fig. 45.

The carbons are secured in clamps, *B*, on supports, *C*, the supports being movable in guides of the frame and controlled by screw-bars, *D* and *E*. The larger clamp is for the positive carbon, in which the crater is formed and which will therefore be the farther clamp from the projector mirror. *F* is the automatic feed, shunted from the lamp leads, having an electromagnet, *G*, which controls the armature, *H*, and which in turn operates the

screw-bars *D* and *E*, through a pawl ratchet and gearing, *J*, when the voltage in the magnet is above 50 to 52 volts. *K* is the series

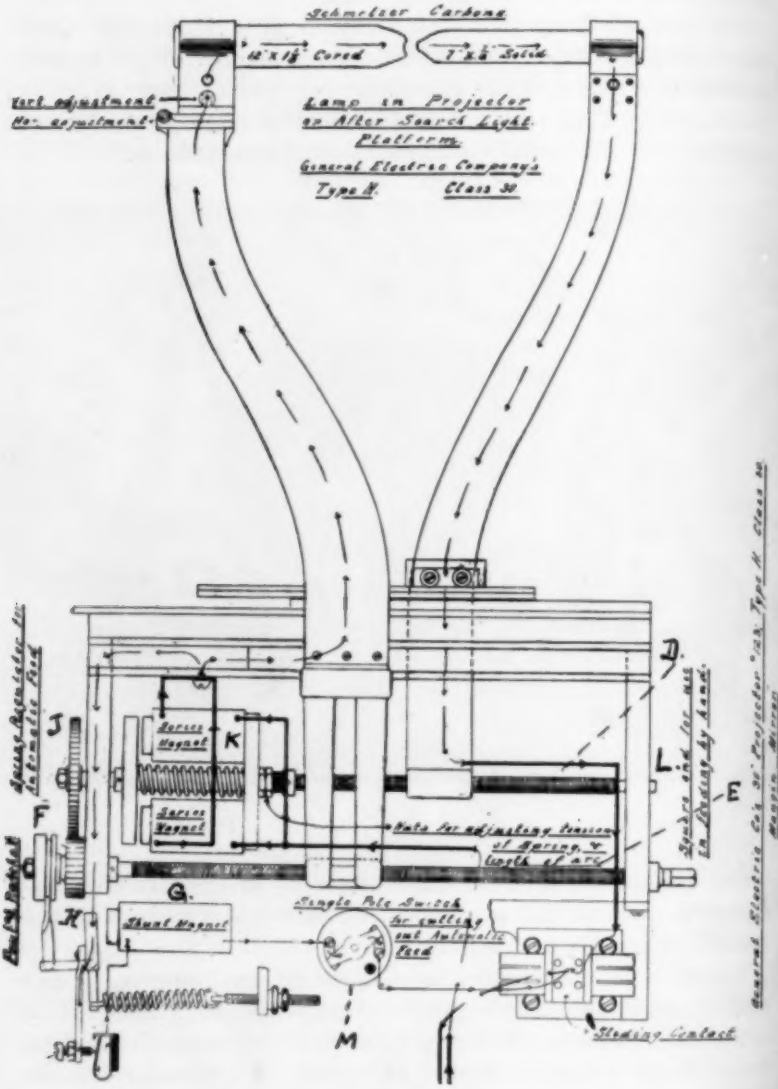

FIG. 45.

striking arc magnet which operates only when the current is much in excess of that required for the lamp. A lug on its

armature embraces the screw-bar, *D*, between two collars, the screw-bar having a small play at *L*, which is independent of the control of the automatic feed. Owing to the gearing the screw-bar, *D*, revolves but one-half as fast as *E*. The screw-bar, *E*, can be turned by a crank socket-wrench, which is removable and can be fitted on a square post at the rear end of the lamp. [Figs. 43 and 44 do not exactly correspond to Fig. 45 owing to differences of construction of the two constructions represented.]

The method of operation is this:

The carbons are adjusted by the crank-wrench to a separating distance of about half an inch. The automatic switch, *M*, should now be closed. The main switch is closed next and, as no current can pass until the carbons touch, the voltage across the carbons up to that moment must be 80 volts. The shunt magnet (called the feed) commences to vibrate, the voltage being greater than 52 volts, and feeds the carbons together by means of the pawl and the gearwheels of the screw-bars. When the carbons touch a heavy momentary current passes (since the resistance is small and voltage at 80), the armature of the striking arc magnet is attracted, pushes back the negative screw-bar and forms ("strikes") the arc. The resistance of the rheostat causes a drop of from 20 to 30 volts as soon as the current passes, and should be adjusted by the lever to the voltage necessary for running the lamp without flaming and hissing.* The voltage required in practice is usually from 45 to 49 volts; the feed will frequently operate at 50 volts. The working current for the lamp varies with the size of the lamp and, incidentally, with the size of the carbons; it is as great as 75 to 90 amperes for the 30-inch projectors, and from 25 to 35 amperes for the 18-inch type.

There is often some flaming of the carbons which cannot be controlled by the rheostat; it is unimportant except from the fact that it decreases the intensity of the light; it will usually disappear of itself. Horizontal lamps have a tendency to flame at the upper edge of the crater, thereby forming the crater on the upper edge of the positive carbon and distorting the reflection; this tendency is corrected in our projectors by a horse-shoe

* The rheostat forms a dead resistance in the line, causing a drop (current multiplied by resistance) equivalent to 30 volts, at which 10 volts are adjustable by the rheostat lever.

magnet, attached to the diaphragm in the projector, which draws down the arc by magnetic attraction.

Some hissing will occur when starting up, especially with new carbons, and the lamp will not quiet down until a good crater has been formed in the positive carbon. This can be obviated by reaming out a crater in the positive carbon with a penknife before putting it in the clamp.

Flaming and hissing are promoted by inferior carbons and are much increased if the carbons have absorbed oil. Those now provided are of the Schmelzer manufacture and are very homogeneous; the positive carbon is usually bored axially and cored with a soft carbon, which materially assists in maintaining a good crater. Negative carbons are sometimes cored, but it is an open question whether this expedient does not conduce to the formation of mushrooms.

Heretofore the carbons were furnished in paper-covered packages which exposed them to moisture and oil, which are readily absorbed by the porous material; they are now packed in tins and should be kept covered and stowed in the store-room.

The momentary current of short circuit, when the carbons touch, is ordinarily heavy and quite sufficient to throw the pointer of the ammeter clear across the scale and against the stops; it need occasion no apprehension if it does not continue; if it does, the switch at the switchboard should be quickly opened. This current may be as much as 50 per cent. above the working current.

Any abnormal current of the searchlight ammeter is usually traceable to either a mushroom on the negative carbon or careless handling of the socket-wrench. In most cases of fusing of the contact plungers in the pedestal there has been direct evidence of an atempt to regulate the feed by hand when the automatic gear was switched on. If the lamp does not feed it is for the reason that there has been a burn-out, or that the lamp itself is not clean, and in 90 per cent. of the cases dirt is the cause; any attempt to remedy matters by use of a socket-wrench, while the current is on, is quite sure to short-circuit the lamp and produce overload.

As a rule it is better to set the carbons before operation and permit no use of the wrench except in focussing; no matter how good may be the man who ordinarily manages the projector some

other man is quite sure to come along and do the mischief; it is the other man who is so untraceable in accidents. The automatic feed is a very desirable expedient and will give good report of itself if not impeded by an impatient use of the socket-wrench. There is rarely any occasion for using the wrench on the *screw-bar* after the lamp is in operation.

The key to good search-light operation and management is thorough cleanliness in all the parts and frequent opportunity for practice by those who are not ordinarily called upon.

The mirrors will spot or frost in time; the action is much hastened on board ship by the practice of exposing them to the

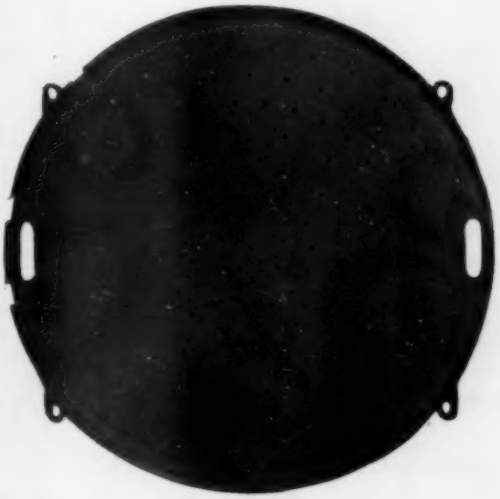

FIG. 46.

rays of the sun while drying out the barrel. There is nothing that will so quickly ruin the silvered surface of a mirror as the action of direct sunlight.

The breakage of front door glasses seems rather more frequent than should be necessary, but, as a rule, it is the result of accident. The glasses are now furnished in strips and effort is being made to have the same number of strips for all front doors irrespective of diameter of projector, in order that they may be supplied on requisition from a mere statement of the type of the projector and the number of the strip. With those now installed the glass-makers cannot intelligently carry out the order unless

a diagram of the whole front, with the dimensions, is furnished from the ship.

Every projector-front should be fitted with an extra outside door made of perforated fibre for the protection of the front glasses. They have been supplied thus far to but one or two ships and on the design of Fig. 46.

Diverging lenses are now plano-convex in the horizontal plane only. The door is made in strips similar to that having the plain glass, each strip being a plano-convex lens.

Parabolic mirrors are now replacing the Mangin type. The Mangin is a double convex lens which is silvered on the back. It has the advantage that for a given focal length the rays of light which it receives are first concentrated on the mirrored surface before reflection. Its disadvantage is that for a given aperture it throws less light than even a concave mirror.

The disadvantage of the concave mirror is the apparently smaller intensity of beam as compared with either the lens or parabolic types. *As looked at* by the *operator* the intensity of the light thrown on a target *appears* greater for both of these latter styles than for the concave, and is greatest for the parabolic. When examined photometrically at the target it will be found that the intensity of the lens mirror is less than that of either the concave or parabolic, while the intensity of the concave and parabolic is practically equal.

The discrepancy, as viewed by the operator, is caused by the fact that concave mirrors throw out a conical penumbra around the beam which interferes with clear vision at the projector, and the illumination of the target appears to be less than that of either the lens or parabolic mirrors.

The parabolic mirror is the most advantageous for searchlight use for the great reason that it lights up the foreground better, and, as we are accustomed to outlining objects by their surroundings, the target is brought out with more sharpness and distinctness of detail. Fig. 47 shows the present style of projector and accessories.

Night Signaling Set.—This device, more commonly known as the ardois, developed an annoying series of faults in the keyboard, due to defective contact of the plungers. In later keyboards, semi-circular in shape and designed for the change from five to four lamps, little fault has been found, and, as a rule, little

trouble is occasioned apart from the slow action of the device. Some difficulty, ordinarily short circuit, is met with at the point where the cable enters the gland of the coupling at the keyboard. It is usually a ground due to breaking of the insulation by a nip and is best remedied by the spring connection for the diving lamp shown in Fig. 36.

More frequently troubles are met with in the cable couplings

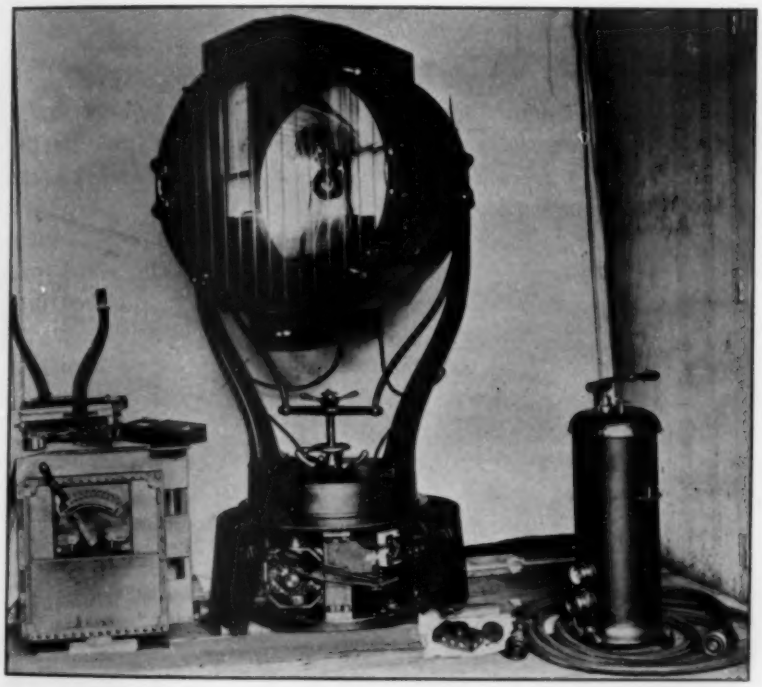

FIG. 47.

themselves. The cables have been made in three sections of 50 feet each, a lamp section from which the wire is branched to the lamp and two plain sections. Each plain section is provided with a male and female coupling in which the contacts are made for the separate wires of the cable, a guide and pin insuring proper entrance. The lamp section has a female coupling only. Although fitted with secure water-tight gaskets water often works into the inner chamber of the coupling and short-circuits

the contacts. Covering with painted canvas is only tentative and has a further disadvantage in that it holds in the water when it has entered.

There is no real necessity for more than one coupling on the entire cable and it should be the female coupling at the lower end for the keyboard connection. It will be found more satisfactory and quite as serviceable to cut off the two upper couplings on all cables having three couplings, splice the wires and tape the junctions water-tight.

On board of the Indiana, where experiments were made with the couplings, the cable was led to and inside of the military mast, thus protecting all couplings from the weather, except that at the keyboard. Particular attention was paid to making the coupling of the lamp section thoroughly tight, but in a short time it was again found to be full of water. Investigation showed that the water had gotten inside the cable through the joints where the lamp wires branch out; once inside, the water was drawn through the cable by capillary attraction, and then into the coupling; the amount of water so drawn made it necessary to bore a very undesirable hole in the bight of the cable outside of the mast to act as a drain. As an emphatic repetition it can be said that one coupling at the keyboard is all that is necessary, and the quick, sure remedy for troubles with other couplings is to take them off.

There seems to be no successful way of preventing the deterioration of the cable due to the heat of the smokepipe; the only resort is a new piece of cable.

One or two cases of filling the upper part of a lamp with water have been noted. This ought not to occur if the gaskets and lenses are tight. A simple method of obviating the difficulty is to bore a small hole in the diaphragm at the bottom of the lamp and out near the edge where there will be no chance of transmission of light. With this arrangement the lamp ought to drain well.

The keyboards have often been inconveniently placed and should preferably be clamped on the bridge-rail within easy access of the officer of the deck. This will require protection to the keyboard by a hood fitted with a sliding door, of which a nice device is shown (attached to the bridge-rail) in Fig. 48, and is for the semi-circular type of keyboard. No good design of

hood for the circular keyboard has been devised; the main difficulty is that in applying the design of Fig. 48, the hood would be too tall, cumbersome and unwieldy.

FIG. 48.

The desire for a more rapid system of signaling has led to the introduction of the telephotos, shown in Fig. 49, in which the contacts are made by a vertical plunger, whose cap fits over a sleeve and keeps the water out. Merely pressing down the

plunger makes the display for that letter or number, and the time lost in adjusting a lever to the required spot and then switching in the current, as required for the ardois, is obviated. The instrument is mounted on a pedestal and well covered by its hood, within which a lamp is placed. The cable is merely a

FIG. 49.

bundle of wires in a canvas tube wrapped outside with a wire armor.

A set of balls in a trough under the plungers prevents the making of two displays at the same time.

It works well, and the rapidity with which signaling can be done is well up to practical requirements.

Rheostats.—The burning out of rheostats is most frequently caused by a misapprehension of their office. It is popularly said and supposed that a rheostat is for the purpose of cutting down the current which is entering the device with which it is connected, and the argument is bolstered up by the triangular reasoning obtainable from the volt, the ohm and the ampere of Ohm's law. But cutting down the current is the effect of a cause, and that cause is that the voltage is cut down; the current drops in consequence. The resistance produces a drop, fall of potential, numerically equal to that resistance multiplied by the current passing.

This is easily demonstrated in the case of the shunt rheostat used with the dynamo; a voltmeter will always show that the voltage across the wires *entering the field* is seldom greater than 40 to 70 volts for an 80-volt machine of any size. The 10 to 40 volts lost in circuit are mainly due to the drop in the rheostat.*

We employ three types of rheostats:

Controllers, or regulating rheostats, used for turrets, ammunition hoist and ventilating motors (and, in a sense, the shunt rheostat) which regulate by variation of resistance.

* No matter what scientists may say as to the strictness of the analogy between the generator, wiring and electricity as parallelled with the pump, its piping and water, we can bridge over many a knotty point in electrical questions by carrying the analogy to its limit, and the application is various: electromotive force, or voltage, the force or pressure which moves electricity, as compared with pump pressure; the effects of grounds with leaks; of pipe ramifications with circuits; of friction with resistance; the cutting down of pressure by large release; bursting from want of capacity with burning-out; rheostats, with pipe expansion, pipe contraction or valves; all show the main point of the analogy. In dealing with electricity, the simple thoroughfare is to consider it from the standpoint of voltage, pressure, alone and leave out all question of current until we are brought face to face with problems of energy.

What is a volt? An ohm? An ampere? are questions that scientists have not exactly informed us about yet.

We can grasp the fact that a volt is a unit of the kind of pressure that will move a certain quantity of electricity, and that an ampere is a unit quantity of electricity. In most cases, if we get the pressure we will get the quantity of electricity we want as we do a quantity of water from a pump and, in the end, we are not so much concerned always as to what the amount of that quantity really is as long as our pipe or wire has the necessary capacity. There are some exceptions, where current must be considered, but they can readily be isolated.

Starting rheostats, used with motors to control the entering voltage *when starting,* but not intended in any way for either regulation or control of the speed.

Line rheostats, used for tapping off a reduced voltage from the dynamo mains, and used mainly with instruments.

The distinction between a controller and a starting rheostat should be especially remembered as it is of great importance in motor use.

The burning out of *line rheostats* is caused chiefly by grounds in the dynamo circuit, and can be obviated by inserting a large resistance between the contacts of the main line and those used

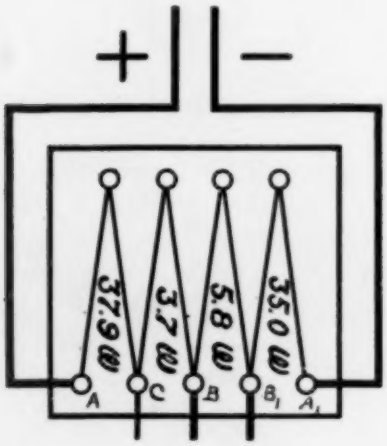

FIG. 50.

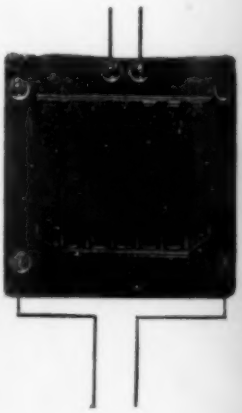

FIG. 51.

for the instrument leads. An ingenious device of the kind is used with the range-finder and shown in Fig. 50. It is required to tap off about 6 volts for the range-finder, and 4 volts for the telephone. *A,A* are the binding posts for the wires leading to the junction box of a lighting circuit. The total resistance of the rheostat wire is 80 ohms (82.4 ohms as shown) which on an 80-volt circuit gives a ready means of obtaining one volt. *B, B,* are the binding posts for the instrument wires; *C* is the binding post for the telephone whose negative wire is attached to that leading back through *B*. Between *A* and *C* the rheostat wire has a resistance of 37.9 ohms, between *C* and *B* of 3.7 ohms, between *B* and B_1 of 5.8 ohms, and between B_1 and *A* of 35.0

ohms. Hence 3.7 volts are tapped off between C and B, 5.8 volts between B and B_1 and there is a drop of 38 volts between A and C, and of 35 volts between A and B.

This arrangement of the large resistances evidently gives a great protection from any overload in the main line as compared with any other place on the resistance wire of the rheostats that the binding posts C, B, and B could be placed. A similar arrangement should be followed whenever rheostats are placed in a line.

Much improvement has been made of late in line rheostats and the types that can be especially recommended are those of the Carpenter designs shown in Fig. 51. These usually have a ribbed plate of cast iron on the unribbed side of which is the resistance wire embedded in enamel. The wire is first put in place, then covered with enamel powder and baked at a high temperature. The radiating surface is very large. The device has the advantage over coil rheostats in that the enamel protects the wire from burning out by radiating the excess of heat on the same principle that water in a pan on a stove prevents the fusing of the solder.

In common parlance the shunt rheostat is called "the box," probably as a distinction from other rheostats. Starting rheostats are usually spoken of as "starting boxes."

The burning out of starting rheostats is explained under the head of motors.

Motors.—The extension of motor use in our ships will require a better knowledge of that device on the part of dynamo men than that which we usually find. They seem to understand the fact that a motor is a dynamo worked backwards, and that the general cycle of operations is reversed, yet they will cause heavy sparking by rocking the brushes *forward* instead of *backward*, and regard the sparking as some peculiarity associated with back electromotive force or other hidden trouble inherent in motors generally.

Motors are tersely and excellently discussed in an article, written for the Institute in 1893, by Lieutenant J. B. Murdock, U. S. Navy. He says:

"All motors on shipboard will naturally fall under the head of constant potential motors, supplied from the ship's mains, and either series or shunt may be used. The series motor is valuable

for its great starting torque,* but has the disadvantage of an irregular speed. In many cases, as in training guns or in other heavy work, steady speed is of no consequence, while the ability to start with a heavy load is all essential. For work of this kind the series motor is the best. If thrown in circuit directly across the mains, it might burn out, the resistance being so low as to allow of an enormous current passing when the motor is at rest. As soon as it commences to move, the current is reduced to safe limits by the counter electromotive force. It is advisable, however, to interpose some resistance to save the motor, this being generally in a starting rheostat, the speed of rotation when once in motion being similarly controlled by resistance. An objection to the series motor is the fact that the speed rises dangerously high if the load is thrown off, the excitation being diminished by the rise of the counter-electromotive force of the motor. The motor makes the vain attempt to attain a speed at which its counter-electromotive force equals the difference of potential of the mains, each increase of speed diminishing the field current and counter-electromotive force and calling for higher speed to attain the voltage of the mains. Theoretically the speed of the series motor under such circumstances is infinite, but the practical limit is found in the fact that friction and internal losses always make something of a load, so that no motor ever runs absolutely light.

"The shunt motor, when made with low armature resistance, preserves a practically constant speed with wide variations of load. It possesses, however, the great defect of having no starting torque. The field coils and armature being in parallel, the former are short-circuited by the latter, and if the motor is suddenly thrown into circuit, the field would not receive enough current to magnetize it, while the armature would probably be burned out by the excess of current passing. Some special starting device is therefore necessary, and a starting rheostat is commonly provided, by which a current is passed through the field coils before the armature circuit is closed at all. The next step is to send the current through the armature in series with a resistance, the latter being gradually cut out as the counter-electromotive force rises from the speed increasing. The special

*Torque is most simply defined as the mechanical couple, due to the forces on both sides, tending to turn the armature.—B. T. W.

purpose for which the shunt motor is adapted is, therefore, starting with a light load and afterwards preserving an approximately constant speed.

"The apparent paradox that the speed of a motor is increased by weakening the field and consequently the counter-electromotive force, must always be borne in mind in considering the speed of motors. The fact that the shunt field remains excited when all load is thrown off keeps the speed down to near its normal value. If the speed could increase, the field being kept constant, the counter-electromotive force of the armature would rise until it reached the potential of the mains. It could, of course, go no higher without running the generator as a motor. The actual limit attained is less than that of the mains, as there is always internal loss and mechanical friction in the motor, energy to overcome which must be derived from the mains, and the speed settles at such a point as to allow the motor to receive just this amount of energy.

"The foregoing is sufficient to enable a conclusion to be reached as to the use of motors on shipboard. If starting torque is essential and constant speed is unnecessary, the series motor is the best, an adjustable resistance being inserted as a protection on starting. For purposes calling for constant speed the shunt motor is best adapted, having a rheostat for use only in starting. In special cases the compound wound motor, possessing in a lesser degree the advantages of each of the others, may be best, but it is noticeable that its complexity is preventing its wide use in commercial practice."

As a rule the chief accident to motors is burning out the armature or field coils from overload in the circuit, for which there are two remedies:

1. A careful elimination of grounds at all times.

2. A circuit-breaking device, as a part of the starting rheostat, to break circuit at either *failure of the line voltage* or *overload*.

The matter of overload needs no other explanation than that the excessive current heats and fuses the wires.

Burning out from failure of the line voltage is the result of thoughtlessness or negligence and occurs in this way: The rheostat resistance is tapped at a series of places to points or blocks. In starting (Fig. 52) the rheostat lever, which is connected to one terminal of the supply circuit at *A*, is moved slowly

from point to point, or block to block, gradually decreasing the resistance in circuit, thus permitting more voltage to the armature of the motor, until the lever gets to the last block, *B*, when all resistance due to the rheostat is cut out and the current leads directly through the lever to the armature, giving it the total voltage of the main line.

There is usually a switch in the circuit. If a break in the main line occurs, thus shutting off the motor supply, the rheostat lever should be immediately placed on the block, *C*, where it was before starting; otherwise when the supply is renewed the motor suddenly receives the full voltage of the line before it has had an opportunity to start, receives an overload, as no back electromotive force is being generated, and the armature burns out.

It is this matter of back electromotive force which is so puzzling to the average attendant, but is readily understood from a brief explanation. Inasmuch as the armature of the motor revolves in a magnetic field, it becomes a dynamo to the extent of the number of its coils, the intensity of its field and the number of revolutions (see page 233), and of its own accord generates an electromotive force opposing that coming from the line; the current to be carried by the armature is by design based on the difference between the electromotive force generated by the motor, and that of the main line—a very small amount by the way—from which it can be easily understood why an armature burns out when suddenly subjected to the full electromotive force of the main line, and for the reason that its wires were never designed to carry such high currents.

Men will generally remember to open the switch, but in most cases of burnt-out armatures which have been investigated it has been found that the rheostat lever was left on the armature stop.

The burning out of the starting rheostat occurs almost invariably from attempts to use it as a speed regulator. The resistance wires are designed to be subjected only to heating effects for the short time necessary for starting, and it follows that if the lever is permitted to remain on any block but *A* or *C*, Fig. 52, the resistance wires will gradually overheat and finally burn out.

When speed regulation is desirable a controller of special design should be used.

The automatic starting rheostat shown in Figs. 52 and 53 ob-

viates both cases of burning out whether of armature or rheostat. There are a number of designs, but the principle involved is practically the same for all.

It consists, Fig. 54, of a hand lever, *H*, and spring lever, *S*, on a common pivot and working through a stiff spring, *K*. *A* is a double pole switch on the main line, *B* is the lead to the shunt field of the motor whose armature and its connections are diagrammatically represented at *C*.

As long as the automatic mechanism is not interfered with this rheostat can be relied on to protect the motor from all damage, under any conditions of practice, whether by skilled or unskilled hands. The following are the principal features:

1st. It automatically opens the circuit when the E. M. F.

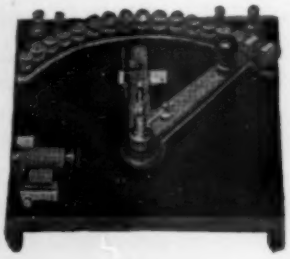

FIG. 52.

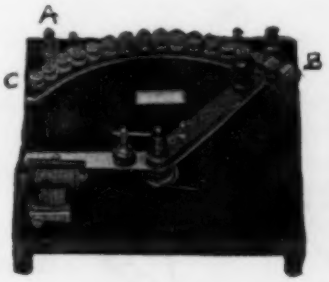

FIG. 53.

(not current) of the supply circuit fails or falls greatly below the normal, required E. M. F.

Referring to Fig. 54, this is accomplished by the fact that, having no voltage, the lectro-magnet, *D*, cannot retain the armature of the spring lever, which immediately assumes the position of Fig. 53.

2d. It automatically opens the circuit when the current through the motor becomes excessively large.

This is accomplished by a second electro-magnet, *E*, whose armature is connected with a catch which holds the spring lever. When the overload passes, it causes the armature of *E* to be attracted, releasing the catch, and the lever assumes the position of Fig. 53.

For the same reason the circuit would be broken if the hand lever was moved too rapidly over the blocks, as excessive current would be caused by so doing.

3d. It is not affected under any conditions when the E. M. F. and current are kept within normal limits.

4th. The electro-magnet, *D*, will not retain the spring lever unless the hand lever is on the starting block, *C*, Fig. 52.

The arc (spark) formed by breaking automatically when running is generally taken up by carbon blocks that can be replaced at any time.

Compound motors have never come into general use for the reason that the armature reaction of a shunt motor will, in most cases, compensate for the falling off of speed due to the heat drop without the use of series windings.

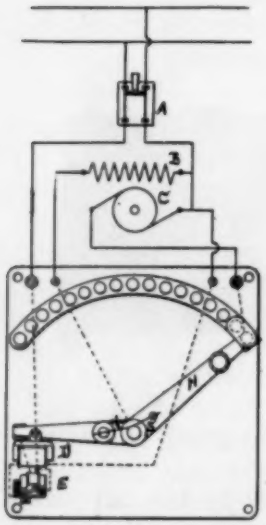

FIG. 54.

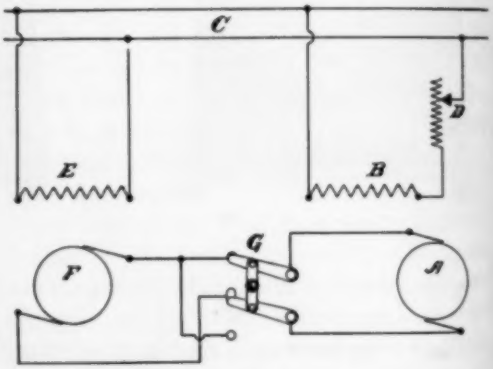

FIG. 55.

Motor use, commercially, has of late been much influenced by the extension of alternate current work, particularly of the two-phase and three-phase types, in which induction motors of simple construction, without commutator or brushes, have overshadowed the constant-potential, direct-current designs.

The high tension and heavy inductions of alternate-current work place it beyond the pale of ship use. Besides, it is difficult of regulation and uneconomical as compared with direct-current for other than long-distance transmission; the minimum of this long distance, as derived from European economics, appears to be greater than five miles.

The use of series (reversible) motors for guns and turrets has never proved successful from the inability to control the speed and regulate the train as compared with hydraulic, pneumatic or steam devices. A subsequent idea of using a positive motion (shunt) motor with a reversible clutch proved but a slight improvement. The problem has been solved in the extremely sensitive motions of the Brooklyn's turrets by separately exciting the fields of both dynamo and motor. The general principle is shown in the diagrammatic representation of Fig. 55. *A* is the dynamo armature, *B* its field, excited by current from the mains, *C*, which are fed by another dynamo. In order to flow through the field coils of *A* the current must pass through the controller, *D*, which is located in the turret and is as simple in its operation as that used by the motorman of a trolley car. The mains, *C*, feed also the field, *E*, of the turret motor, *F*, maintaining a constant potential. The armatures *A* and *F* are connected by direct wires through a reversing switch, *G*.

As the field of the motor, *F*, is constant, its speed will depend entirely on the voltage supplied to its armature by the dynamo, *A*, and the direction of rotation can be changed at will by the reversing switch, *G*.

As the number of circuits of the armature, *A*, are fixed by the design and its speed is constant for the adjustment of the governor of its engine, it follows that the electromotive force which it generates will be proportional to the intensity of its field. This intensity of field is regulated by the controller, which thus forms the key to the whole situation and can be located in the turret in the very best position for practical use.

In order to prevent the turret from turning too far a tripping toe is placed at the limit of its swing which automatically reverses the motor. No difficulty has been developed in the design, nor has there been any occasion for adjustment or repair since the war with Spain, to keep it up to the standard of its original test. Gross and fine train are accomplished without resort to any other expedient.

The dynamos which are installed for use with the motors are compound wound, and have an especial field connection for the change from motor to lighting use. This is not indicated in Fig. 55.

Interior Communications.—This part of the ship's installation is

more complained of, perhaps, than any other for the reason that it is more generally brought to notice and comes under the supervision of so many officers on the ships. The general complaint has been that the instruments are too delicate, require too many repairs, get out of order readily and are unreliable. The complaints have even extended to the point of characterizing them as laboratory instruments. Much of this is true, and efforts are being constantly made to minimize these faults as far as possible on the lines of simplicity in construction, continuity of service and certainty of action. It is to this field that much inventive talent, especially in the service, has been directed, but of the many designs of instruments which have been submitted fully 80 per cent. do not answer service requirements. Of these the large majority have been constructed on the step-by-step principle. A step-by-step instrument is one in which the indications are made successively and which usually depends for its actions upon a train of wheels, or at least upon a combination of cog gearing, which accomplishes the indications required. They are practically inadmissible for the reason that the cogs soon wear in service or break out, and once a tooth slips or is missing the instrument becomes unreliable thereafter. This sort of wear is very much hastened in instruments which require that the electric current shall be kept on, and, in general, it may be said that it is desirable in any instrument that the current should be broken after each indication, excepting in those in which the indications are made by lamps.

A notable example of the step-by-step instruments were the Elliott instruments placed in the Maine. The commanding officer requested that they be taken out of the ship as they were of no practical utility and only occupied needed room on the bridge. These instruments have been installed in trans-Atlantic steamers and have given satisfaction, but require the continued attention of experts.

Engine Telegraph.

Fiske Type.—The instrument embodies, as do all of Lieut. Fiske's inventions, a large number of desirable features for ship's use, but it was found on two ships after long trial to be unreliable, and that even after repairs were made by the manufacturer's experts, it was impracticable to so adjust the instrument that the

indications on the bridge and in the engine-room were the same. If the differences in indications had been equal over the range of the scale there would have been less objection; the differences in indication being known they could be easily applied by the operator or reader, but with variable differences for different readings the intended order became too uncertain.

From a total of six ships in which the instruments have been installed two have reported favorably and four have requested adjustment or repairs. In the two cases above mentioned an old design was installed.

The primary fault is lack of water-tightness in the transmitter where contacts and connections are found to be corroded and oxydized.

A second fault appears to be purely electrical. It is not altogether clear what the fault is, but since the original instrument has been constructed the temperature corrector has been added to the device, showing that errors of resistance affected the readings and, in late repairs, it has been found that many faults have been introduced by the method of wiring, the introduction of small resistances after compensation, and in loose or imperfect contacts.

It is believed that this instrument can be made to operate successfully by perfecting the contacts and so introducing the resistances that there will be no variable. Its principles are good and sound, and it would seem that a change in the device would much relieve its present defects.*

Painter-Morrison Type.—But one set has ever been installed in the service and is now on board the Nashville for trial. The instrument has an escapement somewhat on the stock-ticker principle and comes under the head of step-by-step instruments, though especial attention has been paid to overcoming the usual objections.

Leopold Type.—This combination introduces a visual manual by the use of lamps in addition to a bell signal calling attention. It has never been tried thus far and no information has been obtainable as to its practical working.

* Illustrations of Lieut. Fiske's instruments are not reproduced in this article for the reason that they are shown in detail in his publications on the subject, and to them the reader is referred.

Revolution and Direction Indicators.

Fiske Type.—This introduces the principle of alternating current in instrument devices and is operated by the action of a soft iron inductor (placed on the shaft) revolving in front of the poles of an electro-magnet and connected with indicators which are constructed on the principle of alternating-current voltmeters. The voltmeters soon fail to indicate. In one case which has been brought to notice there has been no practical use obtained from this instrument since its first installation except on original test; all efforts to repair and put it in good working order have proved futile. In another case the magnets were placed so low down in the shaft alley as to bring it in frequent contact with

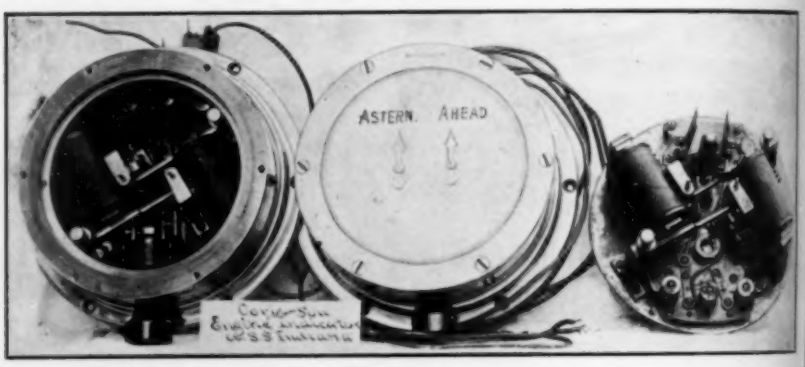

FIG. 56.

bilge water, causing burning out. The magnets were afterwards shifted from their position, but the indications have been very erratic and unreliable.

A particularly cumbersome feature of the design is that there must be a separate collar and inductor on the engine shaft for every indicator installed. This could be avoided, perhaps, by the use of separate magnets, installed about the shaft, each connected to its own indicator. A difficulty with the galvanometer (indicator) arises from the leaking of the liquid with which it must be filled. Available liquids for the purpose seem to be few in number and not readily obtained.

The direction indicator of Lieut. Fiske's device has a separate collar for the magnet which revolves with the shaft and from

which current is led to an indicator self-contained with that for the revolutions. As the pointer merely deflects at each revolution there is no difficulty in having the instrument work properly at all times and, by timing the deflections, the revolutions of the engine can be accurately counted. It is, however, inferior for the purpose to Cory's design, inasmuch as the pointer must be watched while timing, while in the Cory type the deflections are made audible.

Cory Type.—The objection to the Cory type of instrument is that it is not direct reading. Its advantages are that it is simple in construction and does not readily get out of order. The wiring is quite simple and the deflections of the pointer indicate without and difficulty whether the engine is going ahead or astern. In making these deflections a clicking noise is made from which the revolutions can be timed by sound as well as by watching the deflections of the pointer. This particular style of indication is known as the "tick-tack."

Fig. 56 shows the instrument as mounted on the bridge, and Fig. 57 shows diagrammatically the connections and general construction, as follows:

A cogged eccentric, *A*, is attached to the shaft and revolves with it. The cogged wheel, *B*, gears into this eccentric and has an upright, *C*, carrying a cross arm, *D*, which makes contact with springs at *E* and *F*; this combination can swing about a center at *G*, and in each revolution the wheel, *B*, is dragged enough in the direction of rotation of the shaft to make contact at *E* and *F*, accordingly as the engine is going ahead or astern, and always on the same spring for the same direction of revolution. At each of the springs *E* and *F* are connections to two electro-magnets in the indicator, but three wires being necessary as one wire answers as a common return for both. An armature connected to the pointer of the dial is attracted by the magnet, which is energized and is arranged with a sounder to give an audible "tick" at each attraction (each revolution). The current is tapped off a lighting circuit through a line rheostat. It is obvious that the only requirement of operation is that there should be sufficient current in the line to energize the magnets of the indicator, and that it is independent of variable resistances in connections, provided that the requisite energy is supplied. Any number of indicators can be connected in by simply paralleling from the leads from the transmitter at the shaft.

This instrument gives very little trouble; when troubles do occur they are generally from erosion or burning out of the pieces of wire at the contacts of the transmitter, which are very easily adjusted.

Electro-dynamic Type.—This instrument is practically a small dynamo which is geared or belted to the shaft, and which has its

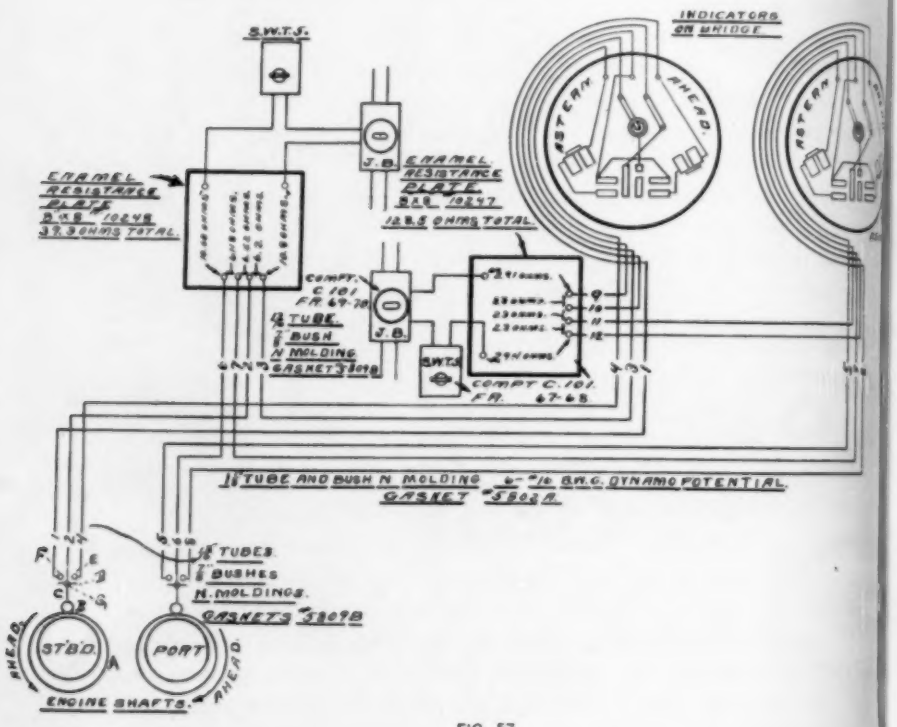

FIG. 57.

field separately excited from a direct lead to the dynamo circuit. It is evident from this arrangement, since the fields are separatley excited, that the voltage produced by the dynamo will depend entirely upon the number of revolutions and the indicators need only be small voltmeters, something on the order of our ordinary portable type. An especial design is used in the actual device. The dynamo can be mounted anywhere conveniently for its shaft connection, can be entirely encased for its

protection and needs only the attention of trimming or shifting the brushes.

The indicator is simply a voltmeter reading both ways from a central zero (similar to the Weston ground detector, Fig. 27), the voltmeter being marked on one side for *ahead* and on the other side for *astern*, the direction of the pointer indicating the direction of revolution of the shaft and calibrated to show revolutions instead of volts. Owing to the fact that voltmeter indications are not reliable at small indications the reading will probably not be correct below twenty revolutions; but as, in ordinary ship practice, we merely wish to know, at such low speeds, the direction in which the shaft is turning and are not particularly concerned as to the number of revolutions that the propeller is making, this objection is really a small one. An instrument of this type was installed in the Brooklyn and has given general satisfaction.

Helm Telegraph.

Fiske Type.—As this instrument consists merely of a transmitter and voltmeter-indicators, for which the current is tapped off a lighting circuit, the transmitter being a resistance in the line, there is very little to get out of order, provided contacts and connections are looked after. But one instance of trouble with the helm telegraph has been brought to notice, and that in a ship where the transmitters not in use were not zeroed as called for by the directions; the transmitter was burned out. A cut-out switch for each transmitter is now installed.

Helm Angle Indicators.

Fiske Type.—The inventor points out that 90 per cent. of all troubles with this instrument will be found in the contact. The contact of the arc is found to become variable and unreliable, thus defeating the utility of the instrument. This is occasioned by wear, vibration, moisture in the damp compartments in which it has to be placed and the friction of the plunger on the wire itself. As in all Fiske indicators, the galvanometers are too sensitive; they are not sufficiently water-tight, inviting the rust and corrosion which are such frequent sources of repair; their adjustments are too delicate and require too much care and attention for the character of the available personnel. Indica-

tors of new designs more in consonance with required practice will remedy many of the complaints made against them. It becomes a particular matter in connection with the helm angle indicator for the reason that the action depends entirely upon the difference in voltage in the two sections of the contact wire, and it must be evident that a very sensitive indicator will take up irregularities of contact and become spasmodic and jerky.

The principles upon which this instrument is founded are sound, but from the nature of the use and the locality in which it must be installed it cannot be recommended for ship use.

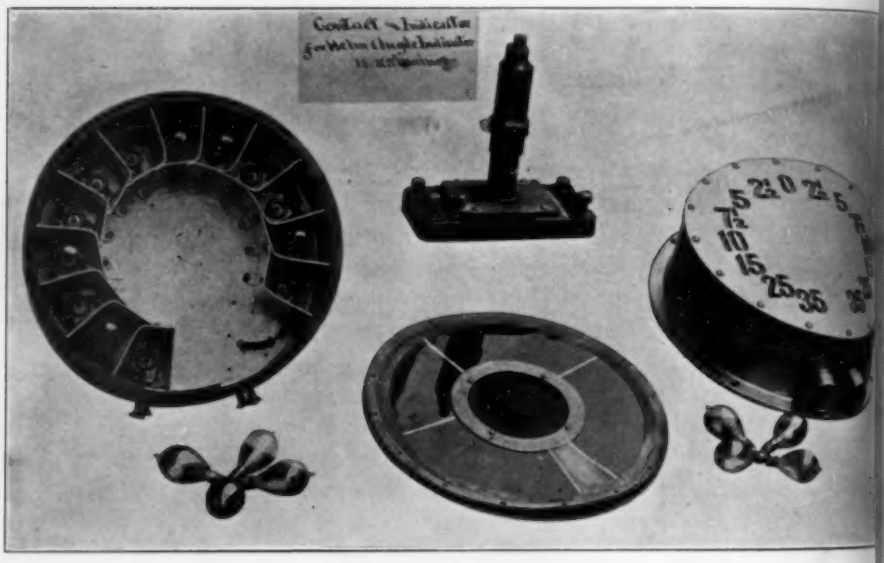

FIG. 58.

Painter-Morrison Type.—This instrument is a modification of that spoken of under engine telegraphs, the motion being communicated to the transmitter by a chain and wheel attached to the rudder head. A bicycle sprocket and chain are usually used. The instrument is on trial in the Nashville, but thus far no complete report has been made on its performance.

Lamp Type.—This is shown in Fig. 58 ready for mounting on a pedestal or bulkhead. Fig. 59 shows the connections with the locations for the action cut-outs, and Fig. 60 shows the arcs on

which contact is made from the plunger carrying the wires. It consists merely of fifteen lamps of 5 c. p. at 80 volts placed in little compartments and shining through a plate of green glass on one side and a plate of red glass on the other side with a piece of white ground glass for the zero indication. The wires are led as in an annunciator, one wire to each lamp with a common return. Contact is made on the arc (to which fifteen wires are

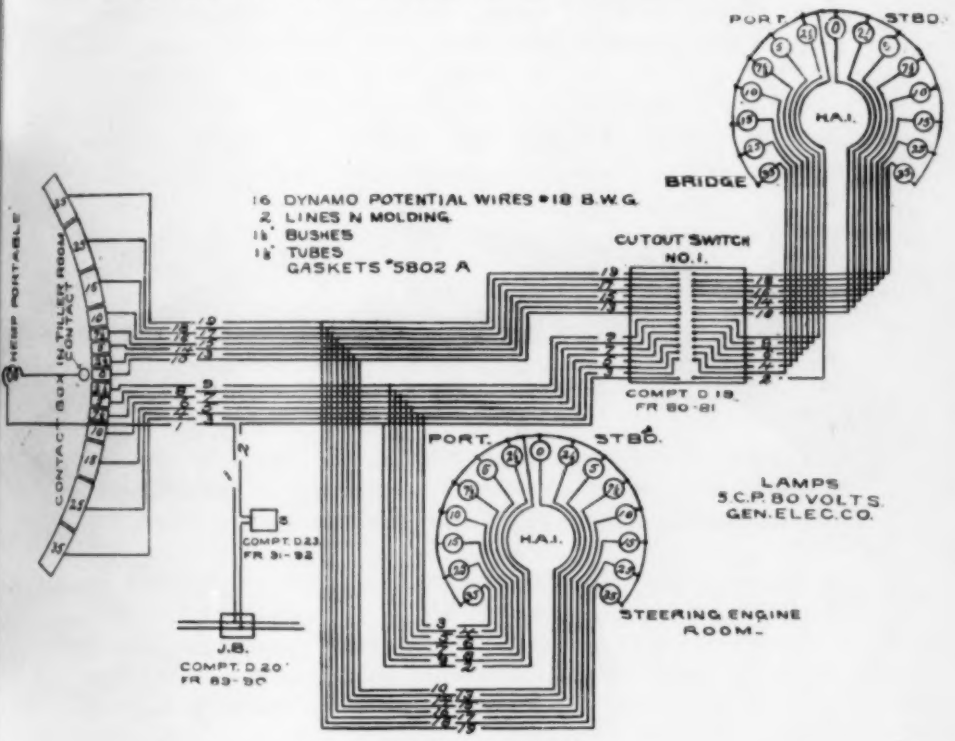

FIG. 59.

connected) by a plunger attached either to the tiller or to a monkey tiller or a yoke secured to the rudder head. The instrument can be recommended as being thoroughly reliable in its operation, has been tested for long intervals and required no repair.

The wiring is done through interior communication cables directly from the points of contact or between connection boxes. It has been urged against this instrument that the indications are not in sufficient number for tactical use, but the different

degrees of helm which are indicated, as shown in Fig. 58, are all that have been found necessary in tactical evolutions and are thought to be sufficient. It has also been objected that the indication is too dim in daylight to be seen at required distances; in all cases which have come under observation the objection does not seem to be well founded. It can be highly recommended as simple and constant in operation which, at least, are two very vital features on interior communication lines.

As a resumé of the difficulties with instruments for the uses mentioned it may be said that present practice indicates the doing away with types depending upon changes of voltage or resistance and substituting devices which are simpler in their care and connections. These, as now proposed, are:

FIG. 60.—CONTACT ARC FOR LAMP HELM ANGLE INDICATOR, U. S. S. MAINE.

Engine Telegraph.—Establishment of prescribed speed by verbal order or mechanical telegraph, the variation from prescribed speed to be signaled as so many turns (up to five usually) *faster* or *slower*. The instrument for this signal is modified from the design of the lamp helm indicator, the transmitter being similar to that of the mechanical telegraph; attention is called by a bell.

Steering Telegraph.—This is similar to that for the engine telegraph, the indicator being marked for angles of helm and one or two especial orders, such as "steady," etc.

Helm Angle Indicator.—The lamp instrument before described.

Battle Order.—Transmitter and indicator are of the lamp type and on the general principle of the lamp helm angle indicator.

Range Indicators.—Are similar to those for the battle order.

Each type necessarily requires its own especial construction,

though all are the same in general principle. The apparent disadvantages of lamp types is their bulk.

There is an objection to the engine telegraph in that it requires the use of the mechanical as well. As long as the leads for mechanical telegraphs are short, they work well; but when complicated, as in large ships, or where the leads are long and require to make a number of turns, they must be looked after continually.

General Alarm.—Difficulties have been reported with the types installed:

First, from giving alarms under ordinary shocks and vibrations in the ship, especially at gun practice. This feature has been overcome to a marked extent by the introduction of a catch similar to that used in the construction of annunciators.

Second, in failure of operation, which can be mostly attributed to lack of voltage in the line.

Alarm-gongs, as a rule, will not operate under less than 15 volts, and unless the batteries are in good condition and up to voltage this difficulty will generally appear. As a rule, the general alarm system should be placed entirely on the transformer with a battery connection as a preventer.

There has been great difficulty in getting a satisfactory gong. The electrical type is better and more certain in operation than the electro-mechanical types, but owing to the large amount of repair which has been called for in this system, the electro-mechanical gong has practically been adopted. The gong should be 12-inch single-stroke. All double-stroke gongs soon get out of order and require replacing. There is an important point in the installation of alarm gongs which has been much lost sight of, and that is that they should not be operated by an ordinary push button. Alarms have frequently been sent in when cleaning the push buttons, especially in chart houses, and in many instances it has been found necessary to entirely insulate the spring from the contact by introducing a wedge of hard rubber. The easy way out of this difficulty is to entirely encase any arrangement for ringing alarms which can be accidentally touched or handled by the men. The uncovered push button is inadmissible in any case. Failure to operate can frequently be remedied by adjusting the tension of the springs.

Batteries and Transformers.—The batteries furnished are made

up of the Gonda or Sampson modifications of the Leclanche cell. This type of cell has a high electromotive force (about 1.43 volts) and low internal resistance (about ¼ ohm), giving it the capacity of sending a strong current comparatively.

It has the great disadvantage that it polarizes very rapidly on closed circuit and the voltage soon drops below required working limits; it is only available, therefore, for uses requiring a strong current for a brief time.

This fact affords a solution to the mysterious failure of alarm gongs and bell calls which occurs from time to time on board ships; it is generally due to an insidious polarization of the batteries by grounds which complete and close the circuit through the cells. It is not that the batteries have given out, but that they are polarized and the condition will be evidenced by a deposit of bubbles (hydrogen) on the carbon elements; if the end battery connections are broken for a couple of hours the cells will recover their normal voltage.

The indication that the battery has run down and needs recharging with sal ammoniac is a milky color of the cell fluid. The jars should always be kept full and the liquid clear. Dipping the zincs in mercury will prolong their life.

The troublesome feature of polarization of batteries by grounds is the great argument in favor of transformers, for grounds have but slight influence on the voltage generated by the transformer and appear only as overload. The transformer is intended for general use on the lines, the batteries to be kept in reserve for emergencies.

The voltages commonly required are about 6, 12 and 20, and can be obtained from any transformer by fitting two extra brushes; it will be found to produce no sparking. As frequently installed, a double-throw, double-pole switch is provided by which either the battery or transformer can be switched in as desired. There is a disadvantage in this arrangement in that lines for small bells require only 6 or 12 volts usually and the higher voltage of the transformer—necessary for the general alarm system—soon burns out the vibratory contacts.

It is better to fit separate brushes for tapping off the required voltages and connect the brush leads to the individual lines through a battery transfer switch, as shown in Fig. 61, which can be expanded for any number of circuits desired. This switch has

the distinct advantage of providing a point where the circuits can be readily tested out in detail and where grounds and faults may be localized.

The slopping out of the liquid in batteries on ships which have much motion at sea points out the desirability of the use of dry cells. There are several good forms in the market, of which the non-polarizing, Fortosec and Mesco can be recommended; the E. M. F. is somewhat less than that of the Leclanche. Dry cells do not recover well when polarized and unless, therefore, a transformer is at hand for general use, a number must be kept

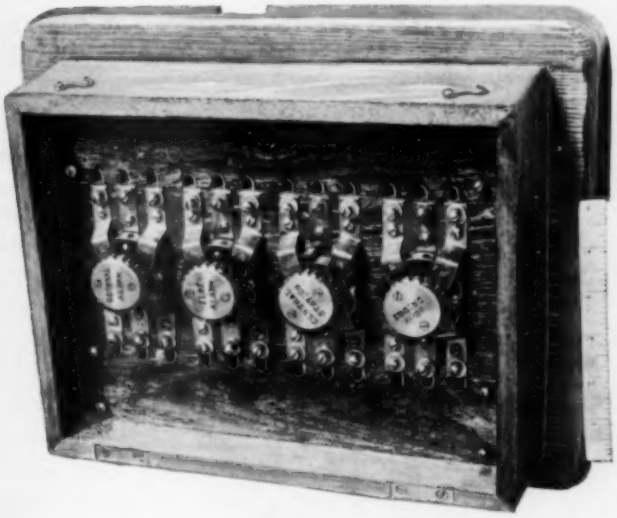

FIG. 61.

in stock to replace those that fail. If care is taken to keep the circuits free of grounds, dry cells are an advantage; they are practically imperative for use in torpedo-boats and destroyers.

Action Cut-outs.—These are now placed on all lines of communications not protected by armor, in order that the unprotected sections may be entirely cut out in action and prevent grounds or short circuits on the lines in use. The device consists of a contact maker operated by a thumb-nut which pushes up the contact springs. The switch is a carbon block of rectangular section enclosed in a brass frame and connected with the thumb-nut. It is merely necessary to move the nut a quarter of a turn to throw the contacts in and out.

Annunciators.—The principal repair and difficulty with annunciators has been in the failure of operation of the drops. In many cases the troubles arise from a collection of dirt and cockroaches about the electro-magnets. Two have been sent up for repair that operated perfectly when brushed out with an ordinary whisk broom. No difficulty has been found with the new types of water-tight devices. Most troubles with annunciators can be avoided by keeping the case locked and occasionally seeing to it that there is no collection of dirt between the electro-magnets.

Cases occur where the failure to operate is due to a too stiff or too weak spring; the remedy is, obviously, to correct the tension.

Testing Out.—The ordinary test devolving on the force is that for insulation resistance, and should be made on all dynamos and circuits every week. For this purpose the simple voltmeter

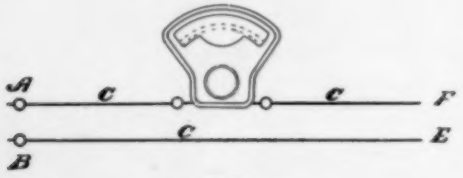

FIG. 62.

test, so little in use, is amply sufficient. To make use of the test the ordinary portable voltmeter is used and connected in, as shown in Fig. 62. A and B are any two points of a switchboard or lighting circuit; V is the voltmeter and C the leading wires. If the ends of the leading wires, E and F, are touched together we will get a deflection in V, which we will call D. If E (or F) is touched to one leg of a circuit and F (or E) is connected to ground we will obtain another deflection, d. The insulation resistance is then:

$$\text{Ins. Res.} = R\left(\frac{D}{d} - 1\right),$$

in which R is the resistance of the voltmeter V. Evidently if $D = d$, the insulation resistance is zero and the circuit has a dead ground.

This method requires but little time as compared with the use of the Testing Set (Wheatstone's bridge), and while not so accu-

rate as the latter, the results are sufficiently so for all practical purposes.

A magneto will ring if there is a dead ground but will not indicate a low insulation; the voltmeter test is therefore preferable, as it shows the approximate insulation resistance in each circuit. Each circuit, whether of dynamo or main lines, should show an insulation resistance, individually, of at least one megohm (1,000,000 ohms), but it must be remembered that dirt, dust and moisture can make it quite possible for a circuit to show a dead ground when the actual insulation resistance is above five megohms. This occurs most frequently when testing dynamo circuits.

Insulation resistance is lowest when the insulation is hot; a current should, therefore, be allowed to flow through a circuit for awhile before testing. The insulation resistance of a dynamo should always be taken after it has been running in order that the circuits may dry out; the shaft end of the commutator should be thoroughly dried with a cotton rag and all dust and dirt removed from the armature and field coils. Moisture and dirt at the joints of the field frame and bed plate will occasion a grounding of the frame.

Conclusion.—The panacea for the great majority of the difficulties with our electric installations on board ship resides in the possession of a competent dynamo force. It is, perhaps, impracticable that the whole force can have the necessary intelligence, and it may be desirable that a part should be under instruction, especially a number detailed from the apprentice class; but there should be at least a competent head whose duty it would be, as a "head dynamo man," to have charge of the entire installation, to direct subordinates in its management and repair and to instruct them in its mechanical and electrical details.

It is apparent that the ships are not sufficiently self-supporting and that adjustments and repairs which should be well within the capacity of the force are held over for that future day when the ship can arrive at a navy yard, and the work be required from the yard department. Meanwhile, "the stitch in time," so vital in engine and electrical faults, tending as they do to become rapidly worse, is not taken, and the cost and magnitude of repair has much increased. On the other hand, in many instances, the equities of the case rest with the ship; the majority of men avail-

able have had no experience with mechanical or electrical details of the installations; those who obtain experience in navy yards usually prefer to remain in civil employment, if good men, by reason of better pay; transfers and discharges prevent the establishment of confidence in those who are made available and the best men obtain warrants or disappear to the navy yard forces or to employment in commercial life.

In order to secure to each ship the competent man to control and look out for our installations, increasing constantly in scope and expense, and to vest him with the necessary authority, he should be given a warrant; he should be a good engineer familiar with the design, operation and repair of short-stroke engines; he should have an electrical knowledge which will enable him to cope with all principles applicable to the installation; he should be conversant with the mechanical details of wiring and accessories.

The incentives of warrant and advanced pay will attract good men to the position; as it is, some of our best men are leaving the service.

APPENDIX A.

Instructions Regarding Electrical Plants.

At the time the ship goes into commission the entire plant is supposed to have been previously tested, with everything in place on board and accepted. Previous to the test for acceptance, the dynamo and engine are supposed to have been inspected at the factories, and the wiring inspected as the work of installation progressed. A general graphic description of the plant will be found in the "Record of Electrical Appliances" which is supplied to the vessel. Nothing remains then but to keep the plant in a thoroughly good and efficient condition during the cruise. To this end the following rules and suggestions for the care and management of the plant will be carried out:

Daily Test.

The ground detector will be kept in use at all times whenever the plant is in operation. This will at once indicate the presence of a leak to earth of any importance. The branch circuit in which the fault occurs must at once be located and the use of that circuit discontinued until it is again in order. It must be strictly borne in mind that to make this detector of any use, the faults must be removed as soon as they appear, or the circuit in which it occurs cut out, for it will not indicate a second fault until the plant is cleared of the first. On the other hand, with proper care, the ground detector is invaluable. In addition to the above, whenever any of the machines are shut down, advantage must be taken of this opportunity to test them for leaks between the different coils, the coils and the frame, and other parts of the machine. If the fault that occurs is of slight importance, it may at times be advisable, after locating it, to allow it to remain until it becomes worse, measuring its resistance, however, and noting its progress.

Used with the new standard switch-board, the branch circuit in which any fault occurs will at once be determined. Each section should be tested at least once daily, and this should be done by throwing off all the sections except the one to be tested. This should preferably be done at such times that the throwing off the lights will not interfere materially with the routine of the ship.

Weekly Test of Search-lights.

These will be operated at least once a week at night to see that everything about them is in good working order and the fact recorded in the journal. At such times care will be taken to have the ground detector connected.

Projectors that are electrically controlled will be tested both by hand and by the electric control. All projectors will be kept at all times ready

for instant use, requiring only the throwing on the switch in the dynamo room.

Quarterly Test of Plant.

Once a quarter measurements must be made of the insulation resistance of the entire plant connected up together, also that of each dynamo and of each of the section circuits leading from the switch-board. At such times advantage should be taken of wet weather if possible. At least once a quarter the entire plant must be operated for a long enough time to see that everything is in working order. At this time everything must be connected up; that is, all lamps, search-lights, motors, etc., within the safe limit of output of the machines.

Quarterly Reports.

These shall contain the results of the quarterly and any special tests that may have been made, as well as the expenditure of all articles used in operating the plant, and its condition. The record should be kept in such a state that the cost of operating the plant can at any time be figured. The behavior and condition of engines, dynamos, lamps, and in fact the entire plant, must be noted, as well as the cause of every fault that occurs. In addition to the above, special reports must be made when necessary for the efficient condition of the plant. The blanks for lamp reports made by the officer in charge must be made and retained on board.

Care and Management of Plant.

Too much care cannot be exercised to see that the entire plant is kept in order. Constant watchfulness on the part of the attendant and observation on the part of the officer in charge to see that the attendants are kept up to their work is absolutely necessary. One fault of itself is frequently of small importance, but when another is allowed to appear in addition, then serious trouble is liable to occur. Too much care cannot be given to the engine. Keep all working parts clean and lubricated. Inspect frequently for any undue wear or lost motion, and keep the drains and other appendages in order. Be economical in the use of oil and other stores. Notice the cause of any unusual noise about the engines. In long leads of pipe, with many bends and branches usually found on shipboard, more or less condensation takes place; this, together with the fact that steam aboard ship is more or less wet, requires that every precaution should be taken to prevent water getting into the cylinders, which in high-speed engines will do much damage in a very short time. The tachnometer will not ordinarily be used even if supplied; the shaft portable speed indicator will ordinarily answer every purpose. *Be particularly careful on starting to run slow until warmed up and water out of cylinders.*

Every engine belonging to the electric plant, boat outfit, etc., should be turned over by hand every day when not in use, and the fact noted in dynamo journal.

In starting engine, the dynamo brushes should be raised. After engine is running smoothly see that brush holders have not been shifted from

marked positions, and see that main switch is open. Lower brushes, and if dynamo has switch in shunt field, close it. Adjust brushes until there is no sparking, noting voltage at same time; then close main switch, noting that all section switches are open. Throw on load gradually, attend brushes at each change of load and shift if necessary.

In shutting down dynamo follow the reverse of the above. In cases when it is known that certain lights will be wanted immediately after starting up, a reasonable load will be put on as soon as the engine is running smoothly and before commencing to speed up, in order that the lamps may attain their candle power gradually and their life thereby increased materially.

As regards the dynamo, the commutator and brushes are what require the most attention; that is, the brushes to be kept trimmed and at the neutral points, and the commutator kept smooth and free from uneven wear. All connections kept tight and clean; copper dust, oil, and moisture kept off the machine and the machine properly lubricated. The pilot lamp must always be kept in circuit in case the main safety fuses go. Be on the watch for any unusual heating of the field magnets or any softening of the insulation. In throwing dynamos in parallel care will be taken to see that each machine is poled right and kept on open circuit until the nominal potential is reached before being thrown into circuit. The operation of throwing dynamos in parallel with the naval standard switch-board is as follows: Each dynamo must first be tested separately. It is brought to the proper potential of 80 volts on light load by adjusting the shunt field rheostat. Full load is then thrown on and the voltage should remain the same. If not, it should be adjusted to give the proper voltage by the shunt to the series field. This adjustment should be once made and occasionally verified; too much care cannot be given to it, and once adjusted should not be tampered with. With loads on each dynamo practically the same, and the difference of their potentials less than one volt, the multiple switch may safely be closed and the dynamos will work together. Any inequality of load between them may then be rectified by the shunt field rheostats. The polarity of the dynamos will be shown by these measurements, and, as has been said, should be the same. When one dynamo is to be thrown in parallel with another actually working it may be advisable to divide the load about equally between them and repeating the observations as to potential before throwing them in parallel. All important instruments must be standardized at least once a quarter, if practicable, and the fact noted in the quarterly report.

When not in use the engines and dynamos must be covered.

With the new standard switch-board the following precautions are necessary for its safe and successful working:

1st. No metal, such as screw-drivers, monkey-wrenches or other tools or watch chains, should be allowed near the front of the board. Any neglect of this kind may cause dead short circuits.

2d. Putting more than one plug switch on any one section is positively forbidden, as the use of two might put dynamos in parallel without any equalizing bar.

3d. If any section is not wired up, it is advisable to remove its plug switch entirely.

4th. In throwing a section in circuit it is advisable to first place the plug switch in proper position for putting the section on the dynamo desired, and then close the switch on the common bus bar. In cutting out a section first open the common bus-bar switch and then the plug switch. In changing a section from one dynamo to another, it is best to first break the circuit with the common switch, then throw the plug switch over into proper position and close the common switch. The plug switches are not intended for throw-over switches.

5th. When any section is wired up, but not in circuit, its common switch should be open, and its plug switch open and locked.

6th. When the dynamos are operating singly the multiple switches should be open and the spring clips covered by hard-rubber covers. These covers to be removed before attempting to connect in parallel.

The record book supplied the ship with outfit contains a general graphic description of the plant. The changes will be noted in this book from time to time, so that the thread can be easily picked up. No change will ever be made in the original plan of wiring or extra outlets run without at once notifying the Bureau.

In the dynamo journal the remarks are to be made as complete as possible. The columns of the journal are to be kept as at present, except that the revolutions will not be recorded as long as the plant is in good working condition. The load for each dynamo will be recorded in its proper column at the end of each hour, unless there is an unusual load on at that time, when the average for the hour will be recorded.

All faults or bad working of the plant in any respect must be noted in the journal.

As regards the circuits, careful daily inspection of connections is necessary to keep them clean and tight; also look for deterioration of the insulation of the wires. With new lamps, those requiring the highest voltage to give their rated candle power must be placed as near the dynamo as possible, those requiring lowest voltage farthest off. The lamps farthest from the dynamo must after a time be shifted near the dynamo in order that they may continue to give their normal candle power.

All lights and fixtures in general use should be inspected and cleaned every day. In cleaning fixtures, especially plated ones, scouring or hard rubbing will not be permitted. They should be wiped off with a cloth or chamois skin.

As previously mentioned, the commutator must be kept free from uneven wear. The necessary evil of all continuous current machines is the commutator. Not only must the brushes be trimmed and placed so as to prevent sparking, but they must also have their position changed from time to time in the direction of the length of the armature, so that the entire surface of the commutator will have the same amount of wear.

During target practice the search-light projectors should be trained and clamped so that they will be parallel to the line of fire, if practicable, the door opened in order to save the lenses from the destructive effect of concussion.

The use of files, sand, emery paper, etc., on commutators is prohibited, except in extreme cases, when it will be fully noted in the journal, and then only by the direction and under the personal observation of the officer in charge of the plant. Under no circumstances whatever will these be used unless the brushes are lifted from the commutator.

When a record is being kept of the life of a number of lamps, the fact must be noted in the dynamo journal in such a manner that it will be brought to the notice of a new officer taking charge of the plant.

The safety fuse will not be replaced with the current on, unless it is absolutely necessary. Even then it must be done by skilled hands and with extreme caution, as the slipping of a screw-driver is liable, in such cases, to put the entire part of the ship supplied by that section in darkness.

With the new junction boxes the fuses may readily be replaced without the turning off of the current.

The dynamo journal will be submitted upon the last day of every month for the approval of the commanding officer, and when filled, forwarded by the first favorable opportunity to the Bureau. Unbound journal sheets are furnished for use in dynamo-room. Each sheet is intended to last two days.

The original invoice, when a vessel is commissioned, will show the electric plant as installed ready for operation, the different articles being enumerated. Spare articles and stores should be separated from the installation. Care should be exercised in making quarterly returns that all articles on board connected with the plant are enumerated whether found in the installation, among the spare articles, or in the stores.

APPENDIX B.

SPECIFICATIONS.

GENERATING SETS.

Sets.

1. Each set shall consist of an engine and a generator secured on a common bed-plate and connected by a solid flanged approved coupling through bolted and keyed.

2. The sets as a whole shall be as compact and light as is consistent with a due regard to strength, durability and efficiency.

3. Their gross weight must not exceed one-third (⅓) of a pound per watt of their rated capacity.

4. All parts of the sets must be accessible for examination, adjustment and repair.

5. Suitable arrangements must be provided for effectively lubricating all parts of the sets which require lubrication and for conveniently collecting and recovering all surplus oil.*

*This specification has been recently modified to specify forced lubrication.

6. Oil-guards shall be fitted wherever necessary to prevent oil from being thrown about by the machinery when in motion.

7. They must operate practically without noise, be thoroughly balanced, and run true, and be capable of being run for long periods under full load without undue heating or wear. All nuts liable to work loose to be lock-nuts; all lock-nuts and pins to be secured against working off by a suitable locking device, which will act with certainty to prevent the bolts or parts which they secure from working loose from the vibration or movement of the mechanism.

8. The driving-shafts must be fitted with thrust-collars or other suitable device which will prevent a movement of the shaft in the direction of its length when the set is subjected to the rolling motion of a ship at sea.

9. All spare parts must be made of standard sizes, so that each will fit any set of the size and type for which it is made, and the fact that they do fit must be demonstrated by actual trial when generating sets are tested for acceptance.

10. Contractors must furnish a complete set of tracings of working drawings for each type of generating set supplied, such tracings to be a part of the contract.

11. Any defect clearly due to defective material or workmanship which may be developed prior to the completion of the first year of service, to be made good by and at the expense of the contractors.

12. During tests for acceptance the sets are to be run with a quality of oil similar to that used on shipboard which has been through the filter after having been previously used.

Engines.

13. The engines must be vertical, strongly built, of the very best materials, thoroughly balanced, and of high efficiency and economy. Their efficiency and economy to be determined by means of suitable tests. Unless expressly specified to the contrary, engines must be designed to work most economically with a steam pressure at the engines of 100 pounds per square inch, if compound, and with a steam pressure of 80 pounds per square inch, if simple; the vacuum to be maintained at not less than 25 inches; but they must be capable of working with pressures of twenty (20) pounds above and below the pressures prescribed for most economical operation.

14. The cylinders must be of hard cast iron; the crossheads, connecting rods, shafts, piston and valve rods, and all nuts, bolts, etc., of the best forged steel.

15. Their design must be such that all parts subject to wear shall be accessible for adjustment and repair, and especially those parts which by reason of wear are liable to affect the alignment of the engine.

16. They must be able to bear without injury the throwing on or off of the entire load by quickly making or breaking the external circuit of the generator.

17. Cylinders shall be fitted with relief-valves, arranged to work automatically, in addition to the usual drain-cocks.

18. The engines must be fitted with automatic governors, which shall

be simple in construction and be made of the most durable materials. The governors must control the speed of the engine automatically, the throttle-valve being wide open within the following limits: A variation of not more than two and one-half (2½) per cent. in the number of revolutions will be allowed on any change of load from the total rated output of the generator to twenty (20) per cent. of the same, when the engine is running with a constant steam pressure, which is to be that required for its most economical operation, as prescribed in paragraph 13. A variation of not more than three and one-half (3½) per cent. will be allowed when the steam pressure is varied between allowed limits, under no load or full load. An extreme variation of not more than five (5) per cent. will be allowed when both steam pressure and load are changed between limits of pressure allowed and full and no load.

19. The cylinders and valve-chests must be covered with a suitable non-conducting material and cased with an approved covering. The cylinders must be fitted with indicator-motions.

20. If the engines have more than one cylinder, the work done in each cylinder must be practically equal, when the engines are working at the normal steam pressure and under full load.

21. It is very desirable that the engines shall be capable of continuous running without the use of lubricants in steam spaces.

Generators.

22. The generators must be of the direct-current compound-wound multi-polar type, and be so designed that their external magnetic fields, at full load, shall be inappreciable at a distance of fifteen (15) feet, measured in all directions in a space free from magnetic material; the effect to be determined with a horizontal-force instrument.

23. The field-frame must be divided in a horizontal plane passing through the center of the shaft, the two parts being properly secured with bolts in order that the upper part, with its pole-pieces and coils, can be separately removed.

24. The standard voltage for all generators shall be 80 volts, measured at the terminals.

25. The compounding of each generator must be such that at the designed speed of its engine the voltage shall at no point of the external characteristic curve vary more than one and one-half (1½) volts from 80 volts over the whole range, from no load to full load, both up and down, no change being made in the field rheostat, and the brushes being at the neutral points.

26. The generators shall be capable of operating in parallel.

27. The armature must be thoroughly ventilated, well balanced, and run true, and must be so secured on its shaft that, while admitting of being readily removed when desired, it shall not slip or work loose from any cause while in operation. Its shaft must have large bearing surfaces, which must be efficiently lubricated by self-oiling bearings. A satisfactory arrangement must be made in its bearings to prevent oil from running along the shaft or from being spilled. There shall be no extra pressure upon its bearings due to the magnetic pull of the pole pieces on the armature.

28. The commutator segments must be of hard-drawn or drop-forged copper, insulated with mica, and have ample thickness to withstand wear for a long period. It must have ample brush-working surface and its radiating surface must be sufficient to prevent it from heating to such an extent as to materially affect the temperature of the armature winding through conduction under any load within the capacity of the generator.

29. There shall be no sparking whatever at the brushes when the generator is in operation with a constant load, nor shall there be any detrimental sparking with a change of one-half (½) load, the brushes not being moved.

30. The following are the maximum limits of temperature permissable in the several parts of the generators, after the full-rated output of the generator has been continuously produced for a period of at least four (4) hours: (a) Temperature of field and armature windings above the temperature of surrounding air 60° F. (b) Temperature of commutator above the temperature of the surrounding air 72° F. The temperature of the surrounding air to be determined by means of a thermometer hung three feet from the generator on the side away from the engine and on a line with the shaft; its indication to be read after the heat-run at the moment of stopping. The temperature of the armature and of the field-coils to be calculated from their electrical resistance measured before and after the heat-run. The temperature of the commutator to be determined by placing a thermometer on the commutator as soon as the generator is stopped, covering it with waste and taking its highest reading as the temperature of the commutator.

31. In addition to the heat-run prescribed in paragraph 30, each generating set shall be tested by running it for a period of two hours with an overload of thirty-three (33) per cent. of the full-rated capacity of the generator. The set must be capable of sustaining this overload for the period of time prescribed without injury to any part either of engine or generator. The engine shall have ample power to give the armature the speed necessary to produce the normal voltage, and no part of the generator shall heat to such a degree as to injure the insulation.

32. The windings of the dynamo, both field and armature, must be well protected from mechanical injury, and must be painted with a water-excluding material.

33. The insulation resistance of the generator circuits from each other, of each from the frame, and of the frame from the combination bed-plate, shall not be less than one megohn, the measurements to be taken with pressures not greater than 1000 volts before and after each run. No insulating substance that could be injured by moisture or by a temperature of 200° F. shall be used.

34. The change of voltage at the terminals of the generator as measured on a deadbeat voltmeter shall not exceed ten volts when full load is suddenly thrown on or off.

35. The field rheostats must have sufficient range to compensate for the increased resistance of the field coils due to their heating. They must be mounted in incombustible frames.

Incandescent Electric Lamps.

1. Lamps will be classed as follows:

Standard lamps.

Instrument lamps.

2. The following are the standard lamps allowed:

16 candle power, clear.

16 candle power, frosted.

32 candle power, clear.

150 candle power, clear.

3. All standard lamps must conform to the following specifications:

First. Their principal, external, over-all, dimensions must be in exact conformity with the design approved by the Bureau, November, 1896, and February, 1897. [Blue print No. 827 C.]

Second. They must be of the best quality and finish and uniform in size; the bases must fit and be interchangeable in the standard socket.

Third. All leading-in wires and anchors must be fused in the glass; all anchors must be made of metal.

Fourth. The filaments must be centered in the bulb and must not droop when the lamps are run in a horizontal position.

Fifth. Each lamp must be marked on the inside of the bulb with the date of manufacture, and must have its rated candle power, the voltage necessary to give this candle power and the name of the manufacturer conspicuously labelled on the outside of the bulb.

Sixth. The material used for cementing the bases to the bulb must be so treated as to ensure against danger of short circuiting the lamp when exposed to moisture. When porcelain is used all holes must be filled.

Seventh. They must be designed for 80 volts, the rated candle power to be given at not less than 78 nor more than 82 volts. No fraction of a volt beyond these limits will be permitted.

Eighth. The efficiency of all 16 c. p. and 32 c. p. lamps must not be less than $3\frac{6}{10}$ nor more than 4 watts per candle power, and that of 150 c. p. lamps not less than $3\frac{2}{10}$ nor more than $3\frac{6}{10}$ watts per candle power, the efficiency to be measured when the lamps are new.

Ninth. The contractors shall guarantee that all lamps supplied will have an average life of at least 600 hours, and that the rated candle power shall not have decreased more than 20 per cent. after burning for this length of time at the initial potential.

4. *Instrument Lamps.*—The following are the standard types allowed:

5 candle power, 80 volt, clear.

1 candle power, 10 volt, clear.

5. Instrument lamps must conform to the following specifications:

First. Their principal, external, over-all dimensions must be in exact conformity with the designs approved by the Bureau, February, 1897.

Second. They must be of the best quality and finish and uniform in size; the bases must fit and be interchangeable in the prescribed socket.

Third. The material used for cementing the bases to the bulb must be so treated as to insure against danger of short circuiting the lamp, when exposed to moisture.

Fourth. The rated candle power must be conspicuously marked on the outside of the bulb and the voltage and amperage necessary to give this candle power must be etched on the glass.

6. *Tests.*—Before acceptance a test lot will be selected at random from the lot of each type of lamp delivered as follows:

From lots not exceeding 50 lamps, all lamps.

From lots exceeding 50, but not exceeding 500, 50 lamps.

From lots exceeding 500 lamps, 10 per cent. of the lot.

7. The test lot will be subjected to the following tests:

(a) For design, dimensions and construction.

(b) For vacuum, by trembling of filament and spark from an inductorium.

(c) For voltage and efficiency when rotating at a speed of 180 revolutions per minute.

(d) For rated candle power, by standard photometer.

8. A secondary standard lamp, standardized from the Bureau's standards, will be used in the tests.

9. A failure of 30 per cent. of the test lot to comply with foregoing specifications will cause rejection of the lot represented by that test lot.

10. All lamps whose bulbs shall burst or whose filaments shall break or burn out under test, or which have been found to have been injured in transit will be rejected from the delivery and must be replaced at the expense of the contractor.

11. When test lots are selected at the contractor's works by an Inspector appointed by the Bureau, the lots so selected shall be immediately sent, free of expense to the Government, to the New York Navy Yard for test, and no test will be made until advice has been received that the delivery represented by such test lots is ready for shipment.

Specifications for Wiring Appliances.

Standard Wiring Appliances.

These shall be of two general classes; water-tight (W. T.) and non-water-tight (N. W. T.).

The following are the standard water-tight appliances:

Junction boxes:

(a) Feeder; (b) main; (c) branch 3-way; (d) branch 4-way.

Switches:

(a) Single pole, 5-ampere; (b) double pole, 25-ampere; (c) double pole, 50-ampere; (d) double pole, 100-ampere; (e) double pole, double throw, 50-ampere (transfer).

Receptacles:

(a) 5-ampere; (b) search-light; (c) controller.

Combination switch and receptacles:

(a) 5-ampere; (b) 25-ampere.

Distribution boxes.

Stuffing tubes:

(a) Box; (b) bulkhead, types L. and S.; (c) deck, types P. and W.; (d) protective deck types P. and W.; (e) washer.

Soft rubber gaskets:

Types A, B, C, D and E.

The following are the standard nonwater-tight appliances:

Junction box:

(a) Branch 3-way; (b) branch 4-way.

Switch.

Receptacle.

Sockets:

(a) Key; (b) keyless; (c) wall.

Specifications for Water-tight Junction Boxes.

Principal parts: the box; the cover; the interior fittings.

The Box.

To be made of brass composition.

Wire Leads.

The wires to be led into the junction boxes through stuffing tubes in the ends and side as follows: Main junction box, two stuffing tubes in each end. Feeder junction box, two stuffing tubes in each end and two in one side. Three-way branch junction box, two stuffing tubes in each end and two in one side. Four-way branch junction box, two stuffing tubes in each end and two in each side.

The cover of the main junction box to be plain, without hole or cap.

The cover and cap of all boxes to be finished on the outside in a very dark, durable color.

Interior Fittings.

The interior insulating blocks of all junction boxes to be of unglazed vitreous porcelain, rectangular in shape. Sheet mica, not less than 25 mils in thickness, to cover the bottom of all boxes, beneath the insulating block.

The interior conductors, leading to the side and end holes of the feeder junction box, to be made of copper having a conductivity of at least 96 per cent. of that of pure copper; and to have a cross section of not less than 0.06 square inch.

The conductors of opposite polarity must be separated at least ⅛ inch from each other and from the metal of the box.

Each conductor leading from the side to the end stuffing tubes to be divided, and to be so fitted that the gaps may be bridged either by copper connecting strips of the same area of cross section as the conductors themselves, or by copper-tipped safety fuses. To be furnished with both copper connecting strips, fuses and micanite cups, for use either with or without fuses.

The main junction box to be without fuses. The two interior conductors to lead direct from one end of the box to the other, on opposite sides of the insulating block; each to have a cross section of 0.06 square inch, and to be made of copper having a conductivity of at least 96 per cent. of that of pure copper; to be separated at least $\frac{3}{16}$ inch, as provided in the feeder box.

The branch junction box to be fitted with two fuses in glass tubes, one fuse in each pole, and both fuses on each branch circuit. The clips for fuses to be of phosphor-bronze, and to have a stout guard secured under and bent outside of each clip, to prevent its being bent out and broken off.

The interior conductors for end stuffing tubes to have a cross section of 0.03 square inch, and to be made of copper having a conductivity of at least 96 per cent. of that of pure copper; to be separated at least $\frac{3}{16}$ inch, as provided in the feeder box. The branch binding posts to be for No. 14 B. & S. G. wire.

The binding straps for wires to be designed to take wire up to and including a diameter of 0.4073 inch (124928 cm.). To have their centers opposite the centers of the stuffing tubes in the box through which the wires are led.

The interior metal parts of all boxes, and the conductors, to be roughly finished; polishing not being required.

Water-tight Switches.

(*a*) *Single Pole, 5-ampere.*

The box to be made of brass composition.

To be finished on the outside in a very dark, durable color.

The branch wires to be led into the box through two stuffing tubes in one end, which will be exactly similar to the side stuffing tubes in the branch junction boxes, the same distance between centers, and fitted with the same stuffing box, glands and washers.

The switch stem to pass through a hole in the cover. This hole to be surrounded by a raised circular wall with a male screw on outside for screw collar. To be packed water-tight by means of a screw collar and washer, with a soft-rubber gasket.

The interior insulating blocks to be of unglazed vitreous porcelain; to be rectangular in shape.

Sheet mica, not less than 25 mils thick, to cover the entire bottom of the box, beneath the porcelain block.

The switch to be quick break. The switch block to be made of porcelain, the contact springs of phosphor-bronze.

(*b*) *Double Pole, 25-ampere.*

The box to be made of brass composition.

The wires to be led into the box through two stuffing tubes in each end, which will be exactly similar to the side stuffing tubes in the branch junction boxes; the distance between centers to be $1\frac{5}{8}$ inch; to be fitted with the same stuffing box, glands and washers.

The switch stem to pass through a hole in the cover. This hole to be

surrounded by a raised circular wall, with a male screw on outside for screw cap. The cap for closing the box water-tight to be secured to the box by a stout chain; the edge of the cap to be milled.

The interior insulating block to be unglazed vitreous porcelain; rectangular in shape.

Sheet mica, not less than 25 mils thick, to cover the entire bottom of the box beneath the block.

The switch to be quick break, double pole; switch block to be of unglazed porcelain, the contact springs of phosphor-bronze. The switch stem to be without a handle, but to be fitted to take and be turned by a standard wrench. The cap for closing the hole in the cover water-tight to be solid, and high enough to clear the end of the switch stem. The cap to be removed when shipping the wrench for operating the switch.

(*c*) *Double Pole, 50-ampere.*

The box to be made of brass composition.

The wires to be led into the box through two stuffing tubes in each end, which will be exactly similar to the end stuffing tubes in the feeder junction box, the same distance between centers, and fitted with the same stuffing box, glands and washers.

The cap for closing the box water-tight to be secured to the box by a stout chain; the edge of the cap to be milled.

The interior insulating block to be unglazed vitreous porcelain; rectangular in shape. Sheet mica, not less than 25 mils thick, to cover the entire bottom of the box beneath the block.

The switch to be quick and break, double pole. The switch stem to be without a handle, but to be fitted to take and be turned by a standard wrench. The cap for closing the hole in the cover water-tight to be solid, and high enough to clear the end of the switch stem. The cap to be removed when shipping the wrench for operating the switch.

(*d*) *Double Pole, 100-ampere.*

The box to be made of brass composition.

The wires to be led into the box through two stuffing tubes in each end, which will be exactly similar to the end stuffing tubes in the feeder junction box, the same distance between centers, and fitted with the same stuffing box, glands and washers.

The switch stem to pass through a hole in the cover. This hole to be surrounded by a raised circular wall, with a male screw on outside, 18 threads to the inch, for screw cap. The cap for closing the box water-tight to be secured to the box by a stout chain; the edge of the cap to be milled.

The interior insulating block to be unglazed vitreous porcelain; rectangular in shape. Sheet mica, not less than 25 mils thick, to cover the entire bottom of the box beneath the block.

The switch to be quick break, double pole. The switch stem to be without a handle, but to be fitted to take and to be turned by a standard wrench. The cap for closing the hole in the cover water-tight to be solid,

and high enough to clear the end of the switch stem. The cap to be removed when shipping the wrench for operating the switch.

(*e*) *Double Pole, Double Throw, 50-ampere.*

The box to be of brass composition.

The wires to be led into the box through two stuffing tubes in each end and two in one side, which will be exactly similar to the end stuffing tubes in the feeder junction box, the same distance between centers, and fitted with the same stuffing box, glands and washers.

The switch stem to pass through a hole in the cover. This hole to be surrounded by a raised circular wall, with a male screw on outside for screw cap. The cap for closing the box water-tight to be secured to the box by a stout chain; the edge of the cap to be milled. Sheet mica, not less than 25 mils thick, to cover the entire bottom of the box beneath the block.

The switch to be quick break, double pole, and double throw, in order to transfer the current from the wires entering at the side stuffing tubes to either pair of those entering at the end stuffing tubes. The interior conductors to be of stamped copper, having a conductivity of at least 96 per cent. of that of pure copper, and of ample area of cross section to carry a current of 40 amperes without heating. The switch stem to be without a handle, but to be fitted to take and be turned by a standard wrench. The cap for closing the hole in the cover water-tight to be solid, and high enough to clear the end of the switch stem. The cap to be removed when shipping the wrench for operating the switch.

SPECIFICATIONS FOR WATER-TIGHT RECEPTACLES.

(*a*) *5-ampere.*

The box cover and insulating block to be in every way similar to the water-tight switch, (a) single pole, 5-ampere box, cover and block respectively, excepting the hole in the cover, which will be adapted for a receptacle plug instead of for the switch stem.

The receptacle plug to be of hard rubber, screwed and cemented into its socket, with contact plates and binding screws on each side. To be fitted with stuffing box and screw collar, so arranged as to be water-tight. Stuffing box and screw collar, so arranged as to be water-tight. Stuffing gland to be identical with those for side stuffing tubes of branch junction boxes. The cap for closing the box water-tight, when the plug is withdrawn, to be secured to the box by a stout chain. The edge of both cap and collar to be milled. The recess of the collar which takes on the top of the wall to be filled with a 1-ply cloth-insertion rubber gasket.

The clips for the receptacle plug to be of phosphor-bronze, and each of the shape of an inverted U, with one end secured and the other free.

(*b*) *Search-light.*

The box to be made of brass composition.

The plug cap to consist of a disk of hard rubber. To be perforated with two holes ½ inch in diameter, and fitted on the washer side with

four brass pins, No. 9 B. & S. G., to secure the metal plug from turning and short circuiting.

The cap plate to be of brass composition.

The plug caps to be fitted in a collar, inside threaded; this collar to screw to the threads on the outside of the wall of the cover.

The metal plugs to consist of a brass block, corners of one side rounded to fit in the rubber disk; the block to be drilled with two holes, in opposite corners, to fit over pins in rubber disk; a hollow post terminal to be turned from the brass block. A copper connection strip to be sweated into a slot in the block.

The copper connection strip for one terminal to have a brass through pin. The lower edges of these connection strips to be rounded off.

The post terminal to have a male thread, 20 to the inch, throughout its length, over which fits a hard-rubber cap, with a central hole carrying a female thread to within ¼ inch of the top, to fit screw thread of post terminal.

This hard-rubber cap to pack the wire water-tight, and to have a shoulder to fit on the cap plate; to be rounded at the top and polished.

The insulating block to be of unglazed vitreous porcelain; rectangular in shape. Sheet mica, not less than 25 mils in thickness, to cover the bottom of the box beneath the block.

The interior conductors to be of copper having a conductivity of 96 per cent. of that of pure copper, to be separated ½ inch; swelled at the ends to receive a large brass strap for securing the wires.

The plug spring clips to consist of two copper plates, soldered into slots in the upper face of each conductor; separated ⅛ inch from each other. Each plate to be bevelled on the inside to admit the plug, and split in the center of its width.

The end stuffing tubes to be fitted as described in end stuffing tubes of junction boxes.

A cap to cover the hole in the cover, when plug cap is not inserted, to be the same as described in feeder junction boxes; to be secured to the box with a stout chain.

(*c*) *Controller.*

The box to be made of brass composition.

The cover to be similar to that for branch junction boxes, and fitted on the inside with a guide pin to correspond with set in coupling contact.

The wires to be led through two stuffing tubes in each end and three stuffing tubes in one side, the same as described in side stuffing tubes of branch junction boxes.

The insulating block to be of unglazed vitreous porcelain, rectangular in shape. The insulating block to have a recess at each of the screw holes to receive the bosses.

The conductors to be seven in number.

Between the two strips of each conductor is to be clamped a clip of phosphor-bronze, turned up and bent into the shape of an inverted U, the inside end to be free.

Combination Switch and Receptacles.

(*a*) *5-ampere.*

The box, cover and insulating block to be in every way similar to the water-tight switch, (*a*) single-pole, 5-ampere box, cover, and block, respectively, excepting that the cover shall have at one end a hole for the switch stem as described under switch, (*a*) single-pole, 5-ampere, and at the other a hole for the receptacle plug, as described under receptacle, (*a*) 5-ampere. The interior fittings to consist of a single-pole 5-ampere switch at one end of the insulating block, and clips for a 5-ampere receptacle plug at the other.

(*b*) *25-ampere.*

The box, cover and insulating block to be in every way similar to the water-tight switch, (*b*) double-pole, 25-ampere, excepting that the cover shall have at one end a hole for the switch stem, as described under switch, (*b*) double-pole, 25-ampere, and at the other, two holes for receptacle plugs; each hole to be as described under receptacle, (*a*) 5-ampere. The interior fittings to consist of a double-pole 25-ampere switch at one end of the insulating block, and two sets of clips for 25-ampere receptacle plugs at the other. The plugs to be the same as for the 5-ampere receptacle, excepting that the contact plates are in one piece, extending like a strap around the end of the plug, with a binding screw on each side.

All of the switches herein described shall be so designed that the switch shall be "on" when the switch handle is lengthwise of the box, and "off" when it stands across the box. In the case of the large switches which are turned by means of a standard wrench instead of by a permanent switch handle, the wrench and end of the switch stem must be so designated that the former cannot be shipped unless it is put on lengthwise of the box when the switch is "on," and across the box when "off."

Distribution Boxes.

The case to be of cast metal, of construction sufficient to withstand rough usage or accident from heavy tools.

The interior fittings to be the same as described in branch junction boxes, and of such number as may be required for the particular compartment or location. Two-ply cloth-insertion rubber packing to separate the fittings from the bottom of the case. The case to have a boss opposite the center line of each branch terminal of the interior fittings. In case any branch of the fittings is not needed for immediate use its boss shall be plugged.

Bosses for conduits carrying the mains to be fitted on the ends, or on the sides near the end, as may best suit the requirements of the location.

Sufficient room for convenience of connecting the mains to be allowed on the inside of the case at the ends.

The cover to be of the same material as the case; to be secured to the case by thumb nuts on swinging screws attached to the sides and corners of the case between the bosses.

The cover to be made water-tight by a gasket of 2-ply cloth-insertion rubber packing.

There shall be no lettering on the outside of the boxes of any of the foregoing wiring appliances.

Junction Boxes (Non-water-tight).

(*a*) 3-way; (*b*) 4-way.

The box, interior fittings and wire leads to be as specified for the branch water-tight junction boxes. No washer to be placed between the cover and top of the box.

The cover to have a hole for the purpose of inspecting the fuses, with a raised circular wall.

The cap to be neat fit over the wall, closing flush with the top of the cover; to be hinged to the cover and secured by a strong snap spring fastened to inside of cap and closing on inside of cover.

Switch (Non-water-tight).

The base to be of glazed vitreous porcelain, circular in shape; to be single-pole, snap, quick-break. The springs to be of phosphor-bronze.

The switch stem and handle to be of metal, insulated from springs and contacts; the handle to screw to the stem and be secured by a headless set screw; the handle to prevent removal of the cover when secured to the stem.

The cover to be of brass composition finished in a very dark, durable color; to be circular in section seating in a recess in the porcelain block, and having a notch in its lower edge fitting over a lug in the porcelain to prevent turning in its seat.

The switch to have a capacity of 10 amperes and to operate in one direction only.

Fuses.

The character of the alloy composing the fuses shall be such that there shall be no reddening or excessive elongation when the current is slowly carried up to the fusing point, which will be at double the capacity. An excess of 50 per cent. is to be steadily carried without any effect.

The fuses for the wall sockets shall be of the copper-tipped commercial pattern, 1⅛ inch between tips and of 4-ampere capacity.

The fuses for branch junction boxes shall be of the copper-tipped glass-tube type and of 4-ampere capacity.

The glass tube shall be 1¼ inch long, $\frac{5}{32}$ inch external diameter, $\frac{7}{64}$ inch internal diameter.

The copper ends shall be ¼ inch external diameter, $\frac{5}{16}$ inch long, spaced ¾ inch apart, and cemented to the glass tube. The ends of the fuse wire to go through $\frac{5}{32}$-inch holes in the center of the copper tips, and soldered to the outside ends.

The switch-board circuit fuses shall be of the standard push-clip copper-tip pattern required for the Board.

The copper shall be No. 18 B. & S. G. The distance between the tips to be $1\frac{7}{16}$ inch.

The rated capacities are to be 10, 15, 20, 30, 40, 50, 60, 75 and 100 amperes.

The fuses to be made up of wire or strip as required.

The rated capacity to be stamped on the face of one of the lugs.

The fuses for feeder boxes shall be of the copper-tipped commercial pattern. The slots in the tips to be for No. 8-32 machine screws. The distance between the tips to be 1 inch. The rated capacities to be 10, 15, 20, 30, 40, 50, 60, 75 and 100 amperes. The fuses to be made up of wire or strip as required. The rated capacity to be stamped on the face of one of the tips.

Fuses for dynamo circuits on the switch-board shall be of the commercial slotted copper-tip type. The slots being at right angles to each other for ⅜-inch bolts. The copper shall be adapted in thickness to the capacity of the fuse. The distance between the tips to be ⅞ inch. The rated capacities to be 25, 50, 100, 200, 300, 400, 500 and 600 amperes. The fuses to be made up of wire or strip as required. The rated capacity to be stamped on the face of one of the tips.

Specifications for Stuffing Tubes.

Stuffing tubes are used for making water-tight the holes in decks, bulkheads, etc., through which wires are run, and are designated as follows:—Box: sizes 14, 18, 26, 36 and 42. Bulkhead: types L. and S., sizes 14, 18, 26, 36 and 42. Deck: types P. and W., sizes 14, 18, 26, 36 and 42. Protective deck: types P. and W., sizes 14, 18, 26, 36 and 42. Washer: sizes 14, 18, 26, 36 and 42.

The terms "Bulkhead," "Deck," etc., indicate where used; the type letters L. and S., whether a long or short tube is required, and P. and W., the character of the deck, whether plain steel or steel covered with wood; the size number expresses in thirty-seconds of an inch, the inside diameter of the hard-rubber lining of the tube. Thus stuffing tube, Deck-P-26, signifies a tube for use in connection with a plain steel deck, the inside diameter of the hard-rubber lining of the tube being $\frac{26}{32}$ of an inch.

All tubes shall be made in strict conformity with the Bureau's designs, of seamless brass tubing of commercial iron pipe sizes, lined with standard No. 1 quality of hard-rubber tubing. The sizes of both brass and hard-rubber tubing to be the same for tubes of like sizes of all varieties, and the fittings for all tubes of the same size to be strictly interchangeable.

The hard-rubber lining to be flush with the brass tubing at the upper end, and to project beyond the brass tubing at the lower end 1⅜ inch, for all tubes excepting box tubes, in which it shall project ⅛ inch only.

All tubes to be fitted at the upper end with standard stuffing glands and washers; and the hard-rubber tubing to be reamed out to take the standard soft-rubber gasket of the proper size for each tube. The gland to have six holes in face, and six in rim, No. 32 drill, for a straight spanner. The spanner to be made of No. 33 Stubs' steel wire, 2¾ inches long. The inner and outer edges of the gland, and the inner edges of the washer to be rounded.

Box Tube.

To have the thread for the gland continued the entire length of the brass tubing.

Bulkhead Tube and Deck Tube.

To have a standard, right-handed pipe thread, corresponding to the iron pipe size of the tube, cut at the lower end of the brass tubing.

Protective Deck Tube.

To have the external diameter of the brass tubing reduced at the lower end, and to have a standard right-handed pipe thread, corresponding to the iron pipe size of the tube, cut at the bottom of the full-sized portion. The sum of the lengths of the pipe thread and the reduced portion, to equal the thickness of the steel deck or armor.

Washer Tube.

To have a straight thread, 14 to the inch, cut on the lower end. To be furnished singly or in pairs, with hexagonal brass nuts, and single or double washer plates as required.

SOFT-RUBBER GASKETS.

To be of rubber composition containing not less than 60 per cent. nor more than 65 per cent. of pure rubber.

To be of five types, which will be designated as follows: Type A, Type B, Type C, Type D, and Type E.

Type A.

The shape to be that of two truncated cones of unequal heights joined base to base; diameter top and bottom $1\frac{5}{32}$ inch, diameter cone bases $1\frac{1}{2}$ inch; the shorter cone to taper from smaller to larger diameter in a height of $\frac{1}{8}$ inch, and the larger cone in a height of $\frac{11}{16}$ inch; total length of gasket $\frac{13}{16}$ inch. To be perforated with a central hole the full length of the gasket.

Gaskets of the type to be designated by the type letter followed by a size number signifying the diameter of the central hole in thirty-seconds of an inch, as A.30, A.36, etc.

There will be a solid gasket of the type to be designated A.0.

Type B.

The shape to be as prescribed for type A; diameter top and bottom $\frac{7}{8}$ inch, diameter cone bases $1\frac{1}{8}$ inch; the shorter cone to taper from smaller to larger diameter in a height of $\frac{1}{8}$ inch, and the larger cone in a height of $\frac{5}{16}$ inch; total length of gasket $\frac{11}{16}$ inch. To be perforated with a central hole the full length of the gasket.

Gaskets of the type to be designated as prescribed for type A, as B.13, B.28, etc.

There will be a solid gasket of the type to be designated B.0.

Type C.

The shape to be as prescribed for type A; diameter top and bottom $\frac{11}{16}$ inch, diameter cone bases $\frac{7}{8}$ inch; the shorter cone to taper from smaller to larger diameter in a height of $\frac{1}{8}$ inch, and the larger cone in a height of $\frac{1}{2}$ inch; total length of gasket $\frac{5}{8}$ inch. To be perforated with a central hole the full length of the gasket.

Gaskets of the type to be designated as prescribed for type A, as C.6, C.20, etc.

There will be a solid gasket of the type to be designated C.o.

Type D.

The shape to be as prescribed for type A; diameter top and bottom ½ inch, diameter cone bases $\frac{11}{16}$ inch; the shorter cone to taper from smaller to larger diameter in a height of ⅛ inch, and the larger cone in a height of $\frac{7}{16}$ inch; total length of gasket $\frac{9}{16}$ inch. To be perforated with a central hole the full length of the gasket.

Gaskets of the type to be designated as prescribed for type A, as D.7, D.14, etc.

There will be a solid gasket of the type to be designated D.o.

Certain ones of the foregoing types of gasket will be required to be perforated lengthwise, with two holes, parallel and of the same diameter, separated equally from each other and from the outer circumference of the gasket. Such gaskets will be designated by a double type letter, followed by a number specifying the diameter of the holes in thirty-seconds of an inch; thus C. C. 6, etc.

Type E.

The shape to be that of a sphere; diameter of sphere $1\frac{15}{32}$ inch. To be perforated by a central hole. Gaskets of the type to be designated as prescribed for type A, as E.32, E.34, etc.

CONDUIT AND MOLDING.

Conduit.

To be of seamless drawn iron or steel tubing of commercial iron pipe sizes, and to have a continuous lining tube of approved insulating material.

Conduit for magazines to be made of seamless brass tubing, to be lined with hard rubber, unless otherwise specified.

Flexible Conduit.

In locations subject to mechanical stress, such as inside of steel masts, or when flexibility is desired, flexible conduit of approved design may be used.

Molding.

Molding will be in two pieces; that part containing the gutters for the wire will be known as molding, and the other part as the backing strip.

To be of well-seasoned wood; where run over hard-wood surfaces to be of the same material as the surface; the bottom of all gutters to be semi-circular in section; width and depth of all gutters to be the same.

Backing strip to be of the same material and width as the molding with which it will be used, perfectly plain, and of a thickness (at least ¼ of an inch) sufficient to cover all rivet heads, bolt heads and nuts; straps and flanges to make a smooth bed for the molding; all capping to be of the same width as the molding, ⅜ inch thick, and to be screwed to the side walls.

Molding for all feeders and wires of 60088 cm. to 124928 cm. inclusive,

will be 3 inches wide, 1½ inch deep, including capping; to have two gutters, each ¾ inch wide and ¾ inch deep, separated by a ¾-inch wall; outside walls to be ⅜ inch.

Molding for wires below 60088 cm. will be ¾ inch wide, 1⅜ inch deep, including capping; to have two gutters each ⅝ inch wide and ⅝ inch deep, separated by a ¾-inch wall; outside walls to be ⅜ inch thick.

Molding for Motor-controlling Circuits.

To be 4⅛ inches wide, 2⅛ inches deep, including capping; to have three gutters, each ⅝ inch wide and ⅝ inch deep, separated by ¾-inch walls; outside to be ⅜ inch; capping to be 3⅝ inches wide by ⅜ inch thick.

Molding for Dynamo Mains and Shunt Rheostat Leads.

To consist of two moldings and a capping of the same width, capping to be ⅜ inch in depth; the first molding (next to backing strip) to have three gutters to carry the terminal and equalizer mains. The second to be 1 inch in depth, to act as a capping to the first; to have two gutters, ⅝ inch wide, for the shunt rheostat lead; the capping to fit the second molding. Gutters to be symmetrically placed and to have same width and depth. Backing strip to be of same width as molding, and to have a depth of 1¼ inch. Dimensions corresponding to leads are tabulated in inches as follows:

Amperes.	Width.	First Molding.				Second Molding.	
		Depth.	Gutters.			Gutters.	
			Width.	Between centers.	Outside wall.	Between centers.	Outside wall.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
50	4¾	1¼	¾	1½	½	2⅜	9/16
100	5½	1½	11/16	1¾	9/16	3⅜	9/16
200	6¼	1 11/16	1⅜	2	9/16	3½	¾
300	7	1⅞	1¼	2¼	⅝	3⅞	11/16
400	7¾	2⅛	1 7/16	2½	11/16	4⅛	1 3/16
500	8½	2 3/16	1 9/16	2¾	¾	4½	1⅜
625	9¼	2½	1 11/16	3	11/16	4⅞	1 9/16

SPECIFICATIONS FOR SOCKETS.

Sockets to be of three kinds: (a) standard key socket; (b) standard keyless socket; (c) wall socket.

Standard key and keyless sockets must conform strictly to the Bureau's designs.

They must be of the spiral-spring type and mounted on porcelain; the spring to be made of No. 11 B. & S. G. phosphor-bronze wire. The shells to be of punched brass 0.016 inch thick. The base of the spiral spring must be firmly secured to a metal plate or divided ring by means of metal binders of a suitable kind, in addition to soldering; and the whole to be secured to the porcelain with ample strength to withstand the torsional strain of screwing a lamp into the socket.

The nozzle in the base to be threaded inside, with ⅜-inch pipe thread. All sockets must fit the standard incandescent lamp.

Dimensions will be: total length 2¼ inches, largest diameter 1½ inch. The spiral spring must be insulated from the shell at the top by an insulating ring of hard rubber.

Instrument Lamp Sockets.

To be of commercial type, with a receptacle to fit the butts of the standard instrument lamp; to be mounted on a porcelain base; the base to be circular or rectangular as directed.

All insulating material to be treated to prevent absorption of moisture.

Key and Keyless Sockets.

To be of commercial type, polished, with D. P. fuse; the receptacle to fit the standard incandescent lamp; to be mounted on a circular porcelain base, 3¼ inches in diameter. The receptacle to be insulated from the shell at the top by a hard-rubber insulated ring; to be finished in dark bronze or silver plate, as required.

When specially directed these sockets will be fitted with the spiral spring described in standard sockets, in lieu of the commercial receptacle.

Attachment plug for commercial wall sockets to be of hard rubber without fuses.

INTERIOR COMMUNICATION.

Wiring Appliances.

Cut-out Switch.

To be of four sizes, taking 5, 10, 15 or 20 conductors, and designated Types A-5, A-10, A-15 and A-20 respectively. The several circuits through the switch to be normally closed, but capable of being simultaneously opened by the throw of an insulating strip, mounted on a spindle running the length of the box.

Box.

To be of cast brass provided with standard box stuffing tubes, as required.

To have internal bosses, supporting the strips of micanite which bear the contact springs.

To be provided with brass hinge bolts and wing nuts for the cover; to be flanged inward at the top to form a seat for the cover washer.

To be secured in place by brass screws sunk in wells, the wells to be packed water-tight by the washer.

Cover.

To be of cast brass having projecting lugs to receive the hinge bolts.

To be fitted with a 2-ply cloth-insertion sheet-rubber washer, held in place by screws.

To show on the outer side the words "Cut-out switch," also the type letter and number, and a serial number.

Contact Springs.

To be of phosphor-bronze, No. 17 B. & S. G., clamped to micanite strips by brass machine screws tapping into terminal blocks beneath the micanite.

Terminal Blocks.

To be of cast brass, having a boss for wire terminal connections.

Spindle.

To be of cast brass, slotted to receive an insulating piece of hard rubber, adapted to actuate the contact springs.

To be firmly held in either open or closed position by a spring of phosphor-bronze, No. 17 B. & S. G.

Wire Terminals.

To be of soft copper, No. 20 B. & S. G., and supplied in sufficient quantity to make the necessary connections in the switch. To have a space for stamping the number of the wire lead.

BATTERY TRANSFER SWITCH.

To be designated Type A, and made with as many sections as required.

Each section to throw into any one of three positions, "Battery," "Off," and "Transformer"; the contacts being made through brass pins set in an insulating disc.

Box.

To be of cast brass provided with standard box stuffing tubes, as required.

To have internal bosses to support strips of micanite bearing the contact springs, and other bosses adapted to form bearings for the spindles of the insulating discs.

To be provided with brass hinge bolts and wing nuts for clamping the cover, and to be flanged inward at the top to form a seat for the cover washer.

To be secured in place by brass screws sunk in wells, the wells to be packed water-tight by the washer.

Cover.

To be of cast brass, having projecting lugs to receive the hinge bolts.

To be fitted with a 2-ply cloth-insertion sheet-rubber washer, held in place by screws.

To show on the outer side the words "Battery transfer switch," the type letter followed by a number showing the number of sections and a serial number.

Contact Springs.

To be of phosphor-bronze, No. 17 B. & S. G., and clamped to micanite strips by brass machine screws tapping into terminal blocks beneath the micanite.

Terminal Blocks.

To be of cast brass, having a boss for connecting wire terminals.

Insulating Discs.

To be of hard rubber; the upper end milled to serve as a handle, the lower end having a projecting brass spindle.

To have two brass pins diametrically opposite each other, passing through and projecting slightly from the disc.

Wire Terminals.

To be of soft copper, No. 20 B. & S. G., with a space for stamping the wire number, and supplied in sufficient quantity to make the necessary connections in the switch; to have a space for stamping the number of the wire lead.

CONNECTION BOX.

To be made in two sizes, taking 20 or 40 conductors, and designed Types A-20 and A-40 respectively.

Box.

To be of cast brass, provided with standard box stuffing tubes, as required.

To have internal lugs to support a porcelain insulator.

To be provided with brass hinge bolts and wing nuts for clamping on the cover, and to be flanged inward at the top to form a seat for the cover washer.

To be secured in place by cap bolts passing through external lugs, or by brass screws sunk in wells; the wells to be packed water-tight by the cover washer.

Cover.

To be of cast brass, having projecting lugs to receive the hinge bolts.

To be fitted with a 2-ply cloth-insertion sheet-rubber washer held in place by screws.

To show on the outer side the words "Connection box," the type number and letter, and a serial number.

Porcelain.

To have ridges on its upper surface, between which the binding posts are fitted.

To rest upon soft-rubber washers, and to be held in place by brass machine screws, passing through suitable bosses.

Binding Posts.

To be of cast brass, having a boss for connecting wire terminals.

Wire Terminals.

To be of soft copper, No. 20 B. & S. G., with a space for stamping the wire numbers; 40 and 80 wire terminals to be furnished with boxes A-20 and A-40 respectively.

Push Button (Water-tight).

To be enclosed in a cast brass case closing water-tight against a soft-rubber washer.

Contact springs to be platinum tipped, and mounted on an insulating plate.

All the foregoing appliances to conform strictly with the Bureau's designs.

Push Button (Nonwater-tight).

To be enclosed in a cast brass case. Diameter of base 2⅜ inches, height of cover not more than ⅞ inch.

Contact springs to be platinum tipped, and mounted on an insulating plate.

Push to be of black hard rubber.

Single-pear Push Button.

To be of black hard rubber, pear shaped, not longer than 3 inches, greatest diameter not more than 1½ inch. The push to be at the lower end, and to be of metal heavily nickeled; contact to be made by a circular plate of metal, heavily nickeled, and held away from the contact screws by a spiral spring; contact screws to be heavily nickeled.

Double-pear Push Button.

To be of black, hard rubber, pear shaped, not longer than 3½ inches, greatest diameter not more than 1¾ inch, thickness of shell not less than 0.15 inch. To have one push on the end and one on the side, and to be of metal, nickel plated; contact points to be platinum tipped.

Triple-pear Push Button.

To be of similar construction to the double-pear push button, not longer than 3½ inches, greatest diameter not more than 1⅞ inch. To have one push at the end, and one at each side, at opposite ends of the same diameter.

Molding.

Molding will be in two pieces, known as molding and backing strips, as described in molding for lighting circuits; to be well seasoned; where run over hard-wood surfaces to be of the same material as the surface, and of the following dimensions:

Two and one-quarter inch molding will be 2¼ inches wide, 1¾ inch deep, including capping; to have one gutter, 1 inch wide; side walls to be ⅝ inch thick.

Two and one-half inch molding will be 2½ inches wide, 2 inches deep, including capping; to have one gutter 1¼ inch wide; side walls to be ⅝ inch thick.

Two and three-fourth inch molding will be 2¾ inches wide, 2⅛ inches

deep, including capping; to have one gutter 1⅜ inch wide; side walls to be $\frac{11}{16}$ inch thick.

All capping to be of same width as molding, and ⅜ inch thick.

All backing strips to be of the same material and width as the molding, perfectly plain, and of a thickness (at least ¼ inch) sufficient to cover all rivet heads, straps, bolt heads, and nuts; and flanges to make a smooth bed for the molding.

Gutters to have the same depth and width; the cross section of the bottom of gutters to be semi-circular.

The foregoing specifications for wiring appliances are here intended as a guide only; the actual specifications cover all dimensions required.

SPECIFICATIONS FOR WIRE SUPPLIES.

1. All wire supplies will be classed as follows:

(a) Lighting wire.

(b) Bell wire.

(c) Cable.

2. The following general specifications apply to all wire and cable:

First. All layers of pure Para rubber must contain at least ninety-eight (98) per cent. of pure Para rubber; must be of uniform thickness, elastic, tough, and free from flaws and holes.

Second. All layers of vulcanized rubber must contain not less than forty (40) per cent. nor more than fifty (50) per cent. of pure Para rubber; must be concentric, continuous and free from flaws or holes; must have a smooth surface and circular section; and must be made to a diameter in the finished conductor that will be in exact conformity with the diameter as tabulated.

Third. All layers of cotton tape must be filled with a rubber insulating compound, the tape to be of the width best adapted to the diameter of that part of the conductor which it is intended to bind. The tape must lap one-half (½) its width and be so worked on as to ensure a smooth surface and circular section of that part of the finished conductor which is beneath it.

Fourth. All exterior braid must be closely woven, and all, except silk braid, must be thoroughly saturated with an insulating water-proof compound which will neither be injuriously affected, nor have an injurious effect on the braid, at a temperature of 200° F. (dry heat), or at any stage of test, the conductor being sharply bent. Wherever a diameter over vulcanized rubber or outside braid is tabulated or specified, it is intended to secure a neat working fit in a standard rubber gasket of that diameter for the purpose of ensuring water-tightness of the joint, and no departure from such tabulated or specified diameter will be permitted.

SPECIFICATIONS FOR LIGHTING WIRE.

Lighting wire will be classed as single conductor and double conductor.

3. *Single Conductor.*—Table of standard dimensions:

Approx. C. M.	Actual C. M.	No. wires in strand.	Size of wire B. & S. G.	Diameter, inches.		Diameter in 32nd of an inch.		
				Over copper.	Over Para rubber.	Over vulc. rubber.	Over tape.	Over braid.
			No.					
4000	4107	1	14	.06408	.0953	7	9	11
9000	9016	7	19	.10767	.1389	10	12	14
11000	11368	7	18	.12090	.1522	10	12	14
15000	14336	7	17	.13578	.1670	10	12	14
18000	18081	7	16	.15225	.1837	11	13	15
20000	22799	7	15	.17121	.2025	12	14	16
30000	30856	19	18	.20150	.2328	12	14	16
40000	38912	19	17	.22630	.2576	13	15	17
50000	49077	19	16	.25410	.2854	14	16	18
60000	60088	37	18	.28210	.3134	15	17	19
75000	75776	37	17	.31682	.3481	16	18	20
100000	99064	61	18	.36270	.3940	18	20	22
125000	124928	61	17	.40734	.4386	19	21	23
150000	157563	61	16	.45738	.4885	20	22	24
200000	198677	61	15	.51363	.5449	22	24	26
250000	250527	61	14	.57672	.6080	24	26	28
300000	296387	91	15	.62777	.6590	26	28	30
375000	373747	91	14	.70488	.7381	29	31	33
400000	413639	127	15	.74191	.7732	30	32	34
			Wires Used in Strands.					
....	1288	.....	19	.03589	.....	.....	.....	.....
.....	1624	.....	18	.0403	.....	.....	.....	.....
.....	2048	.....	17	.04526	.....	.....	.....	.....
.....	2583	.....	16	.05082	.....	.....	.....	.....
.....	3257	.....	15	.05707	.....	.....	.....	.....
.....	4107	.....	14	.06408	.....	.....	.....	.....

4. All conductors to be of soft annealed pure copper wire.

5. No single wire larger than No. 14 B. & S. G. to be used.

6. When greater conducting area than that of 14 B. & S. G. is required, the conductor shall be stranded in a series of 7, 19, 37, 61, 91 or 127 wires, as may be required; the strand consisting of one central wire, the remainder laid around it concentrically, each layer to be twisted in the opposite direction from the preceding, and all single wires forming the strand must be of the diameter given in the American wire gauge table as adopted by the American Institute of Electrical Engineers, October, 1893.

7. The material and manufacture of the strand must be such that the measured conductivity of each single wire forming the strand shall not be less than ninety-eight (98) per cent. of that of pure copper of the same number of circular mils, the measured conductivity of the conductor as a whole to be not less than ninety-five (95) per cent. of that of pure copper of the same number of circular mils.

8. Each wire to be thoroughly and evenly tinned.

9. All lighting conductors shall be insulated as follows:

First. A layer of pure Para rubber, not less than one sixty-fourth ($\frac{1}{64}$) of an inch in thickness taped or rolled on; if taped, the tape to lap one-half of its width.

Second. A layer of vulcanized rubber, of exact diameter as tabulated.

Third. A layer of commercial cotton tape, lapped to about one thirty-second ($\frac{1}{32}$) of an inch in thickness.

Fourth. A close braid to be made of No. 20 2-ply cotton thread, braided with three (3) ends for all conductors under 60,000 circular mils, and of No. 16, 3-ply cotton thread braided with four (4) ends for all conductors of and above 60,000 circular mils. The outside diameter over the braid to be in exact conformity with that tabulated.

10. *Tests.*—Two samples, each 500 feet long, will be selected by the Bureau from the coils of wire to be supplied, and must be sent by the contractors to the New York Navy Yard for test.

The tests will be as follows, failing to meet which, in any particular, will involve rejection of the lot corresponding to the samples.

(a) Both samples, after 24 hours' immersion in sea water, must have an insulation resistance of not less than 1000 megohms per nautical mile.

(b) Test to be at 72° F.

(c) To be tested by the direct deflection method at a potential of not less than 200 volts.

(d) Both samples will be tested for a conductivity of not less than 95 per cent. of that of pure copper, having a cross section of the specified number of circular mils.

(e) Chemical tests will be made to determine the constituents of the different layers of the insulation.

(f) Braid will be tested for water-proof qualities.

(g) Physical tests will be first made for qualities of strength, toughness, dimensions, etc.

(h) The physical and electrical characteristics of the insulation under change of temperature will be tested by exposing the finished conductor for several hours at a time, alternately, to a temperature of 200° F. (dry heat) and the temperature of the atmosphere, during a period of three days.

(i) The tests for characteristics of the insulation will then be repeated and must show no practical deterioration on the results of the former test.

11. *Double conductor.*—Double conductor will be classed as:

(a) Double conductor, plain.

(b) Double conductor, silk.

(c) Double conductor, diving lamp.

12. *Double conductor, plain.*—Each conductor shall be constructed as follows:

First. A copper conductor consisting of seven No. 22 B. & S. G., tinned, annealed, pure copper wires, six of the wires to lay around the seventh. Each single wire to have a measured conductivity of not less than ninety-eight (98) per cent., and the conductor as a whole of not less than ninety-five (95) per cent. of that of pure copper of the same number of circular mils.

One conductor is to be covered with:

First. A layer of vulcanized rubber to an external diameter of one hundred and eighty-one thousandths (.181) of an inch.

Second. With a close braid of No. 60 cotton thread, braided with three ends.

This conductor will form the core and the wires of the second conductor will be laid around it over the braid concentrically and smoothly.

Over both conductors will be:

First. A close braid of No. 60 cotton thread, braided with three ends.

Second. A layer of vulcanized rubber to an external diameter of thirteen thirty-seconds ($\frac{13}{32}$) of an inch, to be vulcanized before braiding.

Third. A layer of commercial cotton tape, about one thirty-second ($\frac{1}{32}$) of an inch in thickness.

Fourth. A close braid of No. 30 2-ply linen gilling thread braided with three ends.

Fifth. A close braid of No. 30 3-ply linen gilling thread braided with three ends.

The fourth and fifth layers of braid to be thoroughly saturated with a water-excluding compound which will not injure the braid or render the conductor less pliable.

13. *Double conductor, silk.*—Each conductor shall be constructed as follows:

First. A stranded copper conductor consisting of seven (7) No. 25 B. & S. G., untinned, annealed copper wires, six wires to lay concentrically around the seventh; each single wire forming the strand to have a measured conductivity of ninety-eight (98) per cent. and the stranded copper conductor ninety-five (95) per cent. of that of pure copper of the same number of circular mils.

Second. A close braid made of No. 80 Sea Island cotton thread.

Third. A layer of pure Para rubber to a diameter of four thirty-seconds ($\frac{4}{32}$) of an inch.

Fourth. A close braid made of No. 60 cotton thread.

Fifth. A close braid made of hard twisted, olive green silk.

Sixth. Two conductors thus constructed shall be twisted together to form the finished conductor.

14. *Double conductor, diving lamp.*—Each conductor shall be constructed as follows:

First. A copper conductor consisting of seven (7) No. 20 B. & S. G., tinned, annealed copper wires, six of the wires to lay around the seventh; each single wire to have a measured conductivity of not less than ninety-eight (98) per cent. and the conductor as a whole of not less than ninety-five (95) per cent. of that of pure copper of the same number of circular mils.

Second. A layer of pure Para rubber, taped or rolled on to a thickness of not less than one sixty-fourth ($\frac{1}{64}$) of an inch; if taped, the tape to lap one-half of its width to a diameter of one hundred and twenty-six thousandths (.126) of an inch.

Third. A layer of vulcanized rubber to an external diameter of one hundred and eighty-six thousandths (.186) of an inch.

Two conductors thus constructed shall then be laid up or twisted together, and filled with jute lateral to a circular section and an external diameter of three hundred and seventy-two thousandths (.372) of an inch. The jute to be saturated with an insulating compound.

Then to be covered with:

First. A layer of vulcanized rubber to a diameter of eighteen thirty-seconds ($\frac{18}{32}$) of an inch.

Second. A close braid of No. 30 3-ply linen gilling thread, braided with three ends.

Third. A close braid of No. 30 3-ply linen gilling thread, braided with four ends.

15. *Tests.*—Unless called for in smaller quantities, all double conductor wire, plain, shall be delivered in lengths of not less than 500 feet; it shall have an insulation resistance between conductors and from each conductor to ground of at least 1000 megohms per 1000 feet after 24 hours' immersion in sea water at 72° F. This insulation must also exist after the whole length has been exposed for fours hours to a temperature of 180° F.

16. Double conductor, silk, shall have an insulation resistance between conductors of at least 20 megohms per 1000 feet, tested in air at a temperature of 72° F.

17. Double conductor, diving lamp, shall have an insulation resistance between conductors and from each conductor to ground of at least 1000 megohms per 1000 feet, after 24 hours immersion in sea water at 72° F. This insulation must also exist after the whole length has been exposed for four hours to a temperature of 180° F. (dry heat).

SPECIFICATIONS FOR BELL WIRE.

18. Bell wire will be classed as:

Bell wire.
Bell cord.

Bell Wire.

19. Bell wire shall be constructed as follows:

First. A copper conductor consisting of one (1) B. & S. G., No. 16, tinned, annealed copper wire whose measured conductivity shall not be less than ninety-eight (98) per cent. of that of pure copper of the same number of circular mils.

Second. A layer of pure Para rubber, taped or rolled on to a thickness of not less than one sixty-fourth ($\frac{1}{64}$) of an inch; if taped, the tape to lap one-half its width.

Third. A layer of vulcanized rubber to a diameter of fourteen hundred and twenty-five ten-thousandths (.1425) of an inch.

Fourth. A layer of commercial cotton tape, about one thirty-second ($\frac{1}{32}$) of an inch in thickness.

Fifth. A close braid of No. 40 2-ply cotton thread, braided with three ends.

Unless called for in smaller lengths all bell wire must be delivered in lengths of not less than five hundred (500) feet.

Tests.—The tests, in addition to ascertaining conformity with the foregoing specifications, will be as follows:

(a) The insulation resistance shall not be less than one thousand (1000) megohms per one thousand (1000) feet, after immersion in sea water at seventy-two (72) degrees F., for a period of twenty-four (24) hours.

(b) The wire will then be subjected alternately, for several hours at a time, for a period of twenty-four (24) hours, to a temperature of one hundred and eighty (180) degrees F. (dry heat) and the temperature of the air.

(c) The insulation will then be tested, after an immersion in sea water at seventy-two (72) degrees F., for a period of twenty-four (24) hours, and must show no variation on the results of the previous test.

Bell Cord.

20. Bell cord will be classed as:

Bell cord, double.
Bell cord, triple.

21. Each conductor will be constructed as follows:

First. A stranded copper conductor consisting of seven (7) No. 25 B. & S. G. untinned, annealed copper wires, six (6) wires to lay concentrically around the seventh; each single wire forming the strand to have a measured conductivity of not less than ninety-eight (98) per cent., and the stranded copper conductor not less than ninety-five (95) per cent. of that of pure copper of the same number of circular mils.

Second. A close braid made of No. 80 Sea Island cotton thread.

Third. A layer of pure Para rubber to a diameter of four thirty-seconds ($\frac{4}{32}$) of an inch.

Fourth. A close braid made of No. 60 cotton thread.

Fifth. A close braid made of hard twisted, olive green silk.

Sixth. Two or three conductors thus constructed will be twisted together to form the bell cord either double or triple as required.

SPECIFICATIONS FOR CABLE.

22. Cable will be classed as follows:

Controller cable.
Interior communication cable.
Whistle cable.
Special cable.

Controller Cable.

23. Each conductor shall be constructed as follows:

First. A copper conductor consisting of nineteen (19) No. 22 B. & S. G. tinned, annealed, pure copper wires, concentrically stranded. Each single wire to have a measured conductivity of not less than ninety-eight (98) per cent., and the conductor, as a whole, not less than ninety-five (95) per cent. of that of pure copper of the same number of circular mils.

Second. A layer of pure Para rubber taped or rolled on to a thickness of not less than one sixty-fourth ($\frac{1}{64}$) of an inch.

Third. A layer of vulcanized rubber to an external diameter of twenty-eight thousand one hundred and thirty-one hundred-thousandths (.28131) ($\frac{9}{32}$) of an inch.

Seven conductors so constructed shall be laid up or twisted together to a circular section, six conductors to lay around the seventh to an external diameter of eighty-four hundred and thirty-eight ten-thousandths (.8438) ($\frac{27}{32}$) of an inch.

Then to be covered with:

First. A layer of vulcanized rubber to an external diameter of ninety-six hundred and eighty-eight ten-thousandths (.9688) ($\frac{31}{32}$) of an inch.

Second. A layer of commercial cotton tape about one thirty-second ($\frac{1}{32}$) of an inch in thickness.

Third. A close braid of No. 30 3-ply linen gilling thread, braided with three ends.

Fourth. A close braid of No. 30 3-ply linen gilling thread, braided with four ends, to a finished diameter of one and one-eighth ($1\frac{1}{8}$) inches.

24. Controller cable shall be furnished in lengths of twenty-five (25) feet, each length to be fitted at each end with a thoroughly water-tight male coupling, the coupling to be in exact conformity with the design approved by the Bureau.

25. Controller cable and couplings must show an insulation resistance between conductors and from each conductor to ground of not less than one (1) megohm after immersion in sea water at a temperature of seventy-two (72°) degrees F. for a period of twenty-four hours.

Interior Communication Cable.

26. This cable shall contain from two to twenty separate conductors, as may be required.

The unit conductor of each cable shall be constructed in conformity with the specifications for bell wire, except that no tape or braid shall be put on; the layer of vulcanized rubber must be of an external diameter of fourteen hundred and twenty-five ten-thousandths (.1425) of an inch.

Each cable is then to be constructed as follows:

The requisite number of unit conductors for each type of cable is to be laid up or twisted together and filled with jute laterals to a circular section, the lay and filling to conform to the designs approved by the Bureau January, 1897.

Then to be covered with:

First. A layer of commercial cotton tape about one thirty-second ($\frac{1}{32}$) of an inch in thickness.

Second. A layer of vulcanized rubber, to be of circular section, and to have a smooth surface in the finished cable and an external diameter in exact conformity with that set forth in the table following.

Third. A layer of commercial cotton tape about one thirty-second ($\frac{1}{32}$) of an inch in thickness.

Fourth. A close braid of No. 20 2-ply cotton thread, braided with three ends, for all cables of less than twelve (12) conductors, and of No. 16 3-ply cotton thread, braided with four ends, for all cable of and above

twelve (12) conductors. The finished diameter must be in exact conformity with that set forth in the table following.

Fifth. One unit conductor in each lay of the cable must be braided with No. 60 cotton thread. This braid to be white and not to be filled with any compound that will affect its color.

27. The following table contains the prescribed dimensions of the standard cables, in accordance with the specified construction of the Bureau's designs above mentioned, No. 825 A, Equipment Department, Navy Yard, New York.

DIMENSIONS OF STANDARD INTERIOR COMMUNICATION CABLE.

Conductors.	Diameter in inches.		Diameter in $\frac{1}{32}$ of an inch.		
	Over Conductors.	Over Tape.	Over vulc. rubber.	Over Tape.	Over Braid.
2	.285	.348	16	18	21
3	.307	.370	17	19	22
4	.344	.406	18	20	23
5	.385	.447	20	22	25
6	.428	.490	21	23	26
7	.428	.490	21	23	26
8	.471	.533	22	24	27
9	.515	.577	24	26	29
10	.559	.622	25	27	30
11	.570	.633	26	28	31
12	.592	.655	26	28	31
13	.604	.666	27	29	32
14	.629	.691	27	29	32
15	.648	.711	28	30	33
16	.670	.732	29	31	34
17	.693	.756	29	31	34
18	.713	.775	30	32	35
19	.713	.775	30	32	35
20	.738	.800	31	33	36

UNIT CONDUCTOR.

Wire Number.	C. M.	Diameter in inches.		
		Over copper.	Over Para rubber.	Over vulc. rubber.
16	2,583	.05082	.081	.1425

Unless called for in smaller lengths, all interior communication cable must be delivered in lengths of not less than five hundred (500) feet.

28. *Tests.*—The tests, in addition to ascertaining conformity with the foregoing specifications, will be as follows:

(a) The insulation resistance between conductors and from conductors to ground shall not be less than one thousand (1,000) megohms per one

thousand (1,000) feet, after immersion in sea water at seventy-two (72°) degrees F. for a period of twenty-four (24) hours.

(b) The finished cable will then be subjected alternately, for several hours at a time, for a period of twenty-four (24) hours, to a temperature of one hundred and eighty (180°) degrees F. (dry heat) and the temperature of the air.

(c) The insulation will then be tested, after an immersion in sea water at seventy-two (72°) degrees F. for a period of twenty-four (24) hours, and must show no variation on the results of the previous tests.

WHISTLE CABLE.

29. Whistle cable will be classed as:

Double conductor.
Triple conductor.

Whistle Cable, Double Conductor.

30. Each conductor shall be constructed as follows:

First. A copper conductor consisting of seven (7) No. 22 B. & S. G. tinned, annealed copper wires, six of the wires to lay around the seventh; each single wire to have a measured conductivity of not less than ninety-eight (98) per cent. and the conductor as a whole of not less than ninety-five (95) per cent. of that of pure copper of the same number of circular mils.

Second. A layer of pure Para rubber, taped or rolled on to a thickness of not less than one sixty-fourth ($\frac{1}{64}$) of an inch; if taped, the tape to lap one-half its width to a diameter of one hundred and six thousandths (.106) of an inch.

Third. A layer of vulcanized rubber to an external diameter of two hundred and forty-six thousandths (.246) of an inch.

Two conductors so constructed are to be laid or twisted together and filled with jute laterals saturated with an insulating compound to a circular section and an external diameter of four hundred and ninety-two thousandths (.492) of an inch.

Then to be covered with:

First. A layer of commercial cotton tape to a diameter of five hundred and fifty-two thousandths (.552) of an inch.

Second. A layer of vulcanized rubber to a diameter of twenty-one thirty-seconds ($\frac{21}{32}$) of an inch.

Third. A close braid of No. 30 3-ply linen gilling thread braided with four (4) ends, to a finished diameter of eight hundred and thirty-two thousandths (.832) of an inch.

Whistle Cable, Triple Conductor.

31. Each conductor shall be constructed as follows:

First. A copper conductor consisting of seven (7) No. 22 B. & S. G. tinned, annealed copper wires, six of the wires to lay around the seventh; each single wire to have a measured conductivity of not less than ninety-

eight (98) per cent. and the conductor as a whole of not less than ninety-five (95) per cent. of that of pure copper of the same number of circular mils.

Second. A layer of pure Para rubber, taped or rolled on to a thickness of not less than one-sixty-fourth ($\frac{1}{64}$) of an inch; if taped, the tape to lap one-half its width, to a diameter of one hundred and six thousandths (.106) of an inch.

Third. A layer of vulcanized rubber to an external diameter of two hundred and six thousandths (.206) of an inch.

Three conductors so constructed are to be laid or twisted together and filled with jute laterals saturated with an insulating compound to a circular section and an external diameter of four hundred and forty-three thousandths (.443) of an inch.

Then to be covered with:

First. A layer of commercial cotton tape to a diameter of five hundred and three thousandths (.503) of an inch.

Second. A layer of vulcanized rubber to a diameter of twenty-one thirty-seconds ($\frac{21}{32}$) of an inch.

Third. A close braid of No. 30, 3-ply linen gilling thread, braided with three ends.

Fourth. A close braid of No. 30, 3-ply linen gilling thread, braided with four ends, to a finished diameter of eight hundred and thirty-three thousandths (.833) of an inch.

Unless called for in smaller quantities, all whistle cable must be delivered in lengths of not less than 500 feet.

32. *Tests.*—The tests, in addition to ascertaining conformity with the foregoing specifications, will be as follows:

(a) The insulation resistance between conductors and from conductors to ground shall not be less than 5000 megohms per 1000 feet after immersion in sea water at 72° F., for a period of 24 hours.

(b) The finished cable will then be subjected alternately for several hours at a time, for a period of 24 hours, to a temperature of 200° F. (dry heat) and the temperature of the air.

(c) The insulation resistance will then be tested, after an immersion in sea water at 72° F., for a period of 24 hours, and must show no variation on the results of the previous test.

Special Cable for Engine Telegraph (Fiske).

33. The transmitter and receiver shall be connected by a cable of two 30,000 cm. (30,858 cm. actual) standard lighting wires, except that they shall not be covered with tape or braid.

Two such wires will be laid up or twisted together with jute laterals saturated with an insulating compound to a circular section and an external diameter of $\frac{8}{32}$ of an inch.

Then to be covered with:

First. A layer of commercial cotton tape about $\frac{1}{32}$ of an inch in thickness.

Second. A layer of vulcanized rubber to an external diameter of $\frac{18}{32}$ of an inch.

Third. A layer of commercial cotton tape about $\frac{1}{32}$ of an inch in thickness.

Fourth. A close braid of No. 20, 2-ply cotton thread, braided with three ends to a finished diameter of $1\frac{1}{16}$ inches.

Special Cable for Range Finder (Fiske).

34. The connections for the range finder shall be run by cable of the following construction:

The conductors shall consist of three (3) 20,000 cm. (22,799 cm. actual) standard lighting wires, and one (1) standard bell wire, except that they shall not be covered with tape or braid.

The four wires so constructed shall be laid or twisted together with jute laterals, saturated with an insulating compound, to a circular section and an external diameter of twenty-eight thirty-seconds ($\frac{28}{32}$) of an inch, the three large conductors to lay around the bell wire.

Then to be covered with:

First. A layer of commercial cotton tape about one thirty-second ($\frac{1}{32}$) of an inch in thickness.

Second. A layer of vulcanized rubber to an external diameter of one and one-sixteenth ($1\frac{1}{16}$) inches.

Third. A close braid of No. 16, 2-ply cotton thread to a finished diameter of one and one-eighth ($1\frac{1}{8}$) inches.

PERMANENT AND MOVABLE ELECTRIC LIGHT FIXTURES.

Permanent Electric Light Fixtures.

1. The standard permanent fixtures are:

Bulkhead.
Bunker.
Ceiling Nos. 1, 2, 3.
Steam tight.
Bracket (single or double).
Double truck.
Binnacle light.

Movable Electric Light Fixtures.

2. The standard movable fixtures are:

Desk light.
Running lights (masthead and side).
Towing light.
Top-light.
Stay light.
Magazine lantern.
Signal lantern (white, green or red).
Battle lantern.
Deck lantern.
Portable.
Cargo reflector.

Navigator's lantern.
Diving lantern.
Telegraph light.

3. All the foregoing fixtures and lights must conform strictly to the Bureau's designs, blue prints of which can be had on application to the Bureau or to the Equipment Department, New York Navy Yard.

Electroliers.

4. Electroliers are to be of commercial types, finished in silver or dark bronze or as directed.

5. Those for torpedo-boats will combine two electric lights with a lamp of hurricane type. Electroliers will be supplied, wired and fitted with shades and key sockets; the shades and sockets to be of standard pattern.

6. Electroliers to be fitted with four stay chains of same finish as the fixture.

Permanent Fixtures.

7. *Bulkhead* and *steam-tight* fixtures will be finished in dark bronze. To be supplied with globe, mounting block and socket, of standard pattern.

8. *Ceiling fixtures No. 1, No. 2* and *No. 3* are intended for general use. The No. 3 to be used as electroliers. All to be finished in oxidized silver or dark bronze or as directed; each to be supplied with globe, mounting block and socket of standard pattern.

9. *Commercial ceiling fixture* of same design as *desk-light* shade-holder, but fitted to a base similar to that of the *single bracket*; to be supplied with shade, mounting block and key socket of standard pattern; to be finished in silver or dark bronze or as directed.

10. *Brackets* to be finished in silver or dark bronze or as directed; to be fitted with shade, mounting block and key socket of standard pattern.

Movable Fixtures.

11. All shades, shade-holders, globes, sockets and gaskets shall be those of the Bureau's standard patterns and designs.

12. *Desk lights*, intended for use in offices and staterooms, will be finished in either silver plate or dark bronze or as directed. All desk lights to be fitted with shade-holder, shade and key socket of same finish.

13. *Running lights*, finished in dark bronze, fitted for two lamps; the *masthead* type to be used for *towing light* and *top light*; *side lights* to be in pairs, one starboard and one port; the colored shades for side and signal lights to be of an approved depth of color, and to be subject to a test for color at the Navy Yard, New York. Running lights, towing and top lights to be fitted with two keyless bronze sockets and two D. 13 gaskets.

14. *Magazine lantern*, finished in dark bronze and fitted for two lamps and reflectors, to show light on four sides. A seat will be provided for regulation magazine candlestick.

15. *Signal lantern*, finished in dark bronze, intended for signal purposes. All signal lanterns to be fitted with keyless bronze socket and D. 13 gasket.

16. *Deck lantern*, finished in dark bronze and intended for general use. It can be used with or without any of its parts, *i. e.* wire guard or steam-tight globe.

17. *Battle lantern* to be similar to deck lantern, but to have in addition a metal shield with slide for the purpose of shutting off the light at the side.

18. All deck and battle lanterns to be fitted with steam-tight globe, keyless bronze socket and D. 13 gaskets.

19. *Portable*, finished in dark bronze. All portables to be fitted with keyless bronze socket and D. 13 gasket.

20. *Cargo reflector*, finished on the outside of reflector in dark bronze, inside in white enamel; to be fitted with four bronze keyless sockets and D. 13 gasket.

21. *Navigator's lantern*, finished in dark bronze, to be fitted with bronze key socket and D. 13 gasket.

22. *Diving lantern*, polished brass finish, to be fitted with bronze keyless socket and two C. 18 gaskets.

23. *Telegraph light*, for lighting mechanical telegraphs, finished in dark bronze, to be fitted with standard instrument light socket, rectangular base, and D. 13 gasket.

Shades and Globes.

24. *Shades.*—Shades to be 3¼ inches in diameter at holder, 6 inches wide at mouth, and 4 inches deep; mouth to have 12 flutes; to be of the best opal glass.

25. *Globes.*—All globes to be the best quality of flint glass; those specified to be ground will be ground on the inside only, and sufficiently to soften the light but not to cut it off to any great extent.

26. *Steam-tight globes.*—Steam-tight globes to be of clear glass, not more than ¼ inch thick nor less than ⅛ inch thick; outside length, 8 inches; outside diameter, 3⅝ inches.

27. *Globes for ceiling fixtures.*—Globes for C. F. No. 1 to be of ground glass, 5 inches in diameter and 6 inches deep; to be not more than ¼ inch nor less than ⅛ inch thick; to secure to the metal collar of the fixture by means of a coarse screw thread, 4 to the inch. Globes for C. F. No. 2 and No. 3 to be either ground or clear, as directed, not more than ¼ nor less than ⅛ inch thick; diameter inside, 7¾ inches; depth inside, 3⅝ inches. To secure to the metal collar of the fixture by means of a coarse screw thread, 4 to the inch.

Lenses.

28. Lenses for running lights to be French Fresnel lenses, the separate pieces to be cut, polished and set in a metal frame. For signal lanterns the pressed lens, carefully polished, will be allowed.

29. All fixtures, lights and accessories to be of the best quality and workmanship; the plating and bronzing to be of the most durable kind and sufficiently heavy to withstand the action of salt water, and shall be subject to test as to the fulfillment of these specifications, at the New York Navy Yard, or as directed.

ACCESSORIES AND INSTRUMENTS.

Switchboard.

1. The design of switchboard in general to be such that any number of dynamos may run singly on the lighting, search-light or motor circuits, or any combination of them in parallel; and any combination of the number of the dynamos may run in multiple on any of the circuits, or any combination of them in parallel.

2. The switchboard to consist of a switchboard proper and two instrument boards, the bases of all to be made of slate or marble of uniform thickness, not less than 1 inch. If slate is used it will be finished with black enamel on all sides.

3. The switchboard proper shall have two common positive bars and as many double negative bars as there are dynamos used in connection with it.

4. The material of the bars to be of copper of high conductivity, the size to be ample for any capacity that may be demanded of them.

5. Allowance to be made in securing the bars to the board to insure against detrimental effects from expansion.

6. Both positive and negative bars shall be permanently connected at the back of the board, and each shall have as many terminals as there are dynamos.

7. There shall be a double-pole switch, of all-drawn pure copper, for each dynamo, connecting the terminals of the equalizing wire and of the negative bus bars with a common equalizer and a common negative bar.

8. The circuits to terminate at the back of the board; conical copper thimbles to be provided for capping the ends of the feeders; the thimbles to fit in conical holes on the back of the board and to be secured by screws.

9. The positive leg to be connected by a single switch to the positive bus bar, and the negative leg by a double-throw shifting switch, by which current is taken from the negative bus bar.

10. The circuit switches to carry 150 amperes unless otherwise directed; the negative bus bars to carry the maximum capacity of their dynamos; the positive bus bars to carry the maximum capacity of all the dynamos connected to either leg. There must be a spring clip fuse between each terminal and corresponding bus bar.

11. Name plates shall be furnished showing the serial number of each circuit, the character and location of its load.

12. The name plates to be placed adjacent to their respective switches and fuses.

13. A name plate is to be furnished showing the name of the vessel to which the switchboard is to be supplied.

14. Each negative bus bar shall have at its upper end a number corresponding to the number of the generating set with which it is connected.

15. The instrument boards will be 12 inches in width and of the same length and thickness as the switchboard proper.

16. The left-hand instrument board to be provided with a voltmeter

for each generating set; the connections to be made directly to the dynamo terminals.

17. The right-hand board to be provided with as many direct-reading ammeters as there are generating sets.

18. A separate board to be provided with a separate voltmeter and ammeter for each search-light installed, the instruments for each circuit to be mounted one above the other, the voltmeters uppermost.

19. Ammeters and voltmeters for the generating sets to be marked with the number of the set; ammeters and voltmeters for search-light circuits to be marked with the name and number of the particular light.

20. The shunt rheostats to be mounted on a separate panel of similar material to that of the switchboard; to be placed in regular order and marked with numbers corresponding to those of the generating sets.

Field Rheostats.

21. Field rheostats are to be constructed with reference to the particular service required of their generating sets, and shall contain no combustible or absorbent material.

22. They must be as compact as possible, be well ventilated, have sufficient range to compensate for the increased resistance of the field coils due to heating, and have the contact points so arranged that the resistance of the field coils can be varied by small amounts.

23. The material of the coils must be such as will resist oxidation and will insure that heating will not affect the constituent metals of its alloy.

24. Each rheostat shall be marked with the factory number, the number corresponding to the generating set with which it is used, and also with the words "high" and "low," to indicate the direction of the motion of the handle required for increased or decreased voltage.

25. Rheostats must be of approved design, construction and operation.

Gauges.

26. All gauges to have a 5½-inch dial, with single Bourdon spring, Union steam-gauge cocks and solid-drawn seamless tube.

27. Steam gauges to be graduated for 0 to 160 pounds inclusive. Vacuum gauges to be compound pressure, and vacuum gauges graduated for 30 inches vacuum and 40 pounds steam.

28. Gauges to be finished in nickel plate.

Cylinder Lubricators.

29. Cylinder lubricators to be of half-pint or pint capacity, as directed.

30. To be double-connection automatic sight feed, for stationary engines, and of standard pattern.

31. The construction to comprise: Oil reservoir; oil filter; water-feed valve; valve to regulate flow of oil; steam tube and condensing chamber; drain valve to draw off water, sight feed glass; indicator glass; oil-discharge pipe; valve to correct pulsation and unsteadiness of feed vent.

32. Each to be supplied with a copy of directions for use and two extra sets of glasses and washers.

33. The finish to be nickel plate.

Ammeters and Voltmeters.

34. To be of the movable coil type; those for use on switchboard or with search-lights to be circular; to be direct reading, and deadbeat without mechanical damper. The scales to be evenly divided over the entire range, beginning at zero. To have no magnetic lag. The temperature correction to be a minimum. The heating effect to be negligible. The parts to be made to gauge and strictly interchangeable.

35. The stops must arrest the motion at the coil and not at the pointer.

36. The scale must be varnished and thoroughly cemented to the support. The pointers to be well balanced and very narrow in the direction of the plane of the scale.

37. Scales for switchboard and search-light voltmeters must read to 125 volts inclusive.

38. Scales for switchboard and search-light ammeters must read to 50 per cent. above the rated load of dynamo or search-lights.

39. Switchboard and search-light ammeters and voltmeters to have water-tight cases, with a special compartment for circuit connections inside the case; the ammeters to be of the shunt type, the shunts to be contained in special water-tight metal cases; the voltmeters to be fitted with a normal index.

40. Portable ammeters must have a scale to 150 inclusive, and be supplied in a carrying case of varnished hard wood.

41. Portable voltmeters must have 15 and 150 scales, and be supplied in a carrying case of varnished hard wood.

Tachometer and Counter.

42. Portable hand tachometers are to be furnished in morocco cases.

43. The scales to be graduated from 100 to 1,000 revolutions.

44. Each tachometer to be supplied with two sets of gear wheels, by which speeds of 50 to 500 and 200 to 2,000 may be indicated.

45. Hand counters are to be furnished in morocco cases; to be of an approved type.

46. Tachometers and counters are to be finished in nickel plate.

Testing Sets and Generators.

47. Portable testing sets are to comprise a Wheatstone bridge, rheostat galvonometer, battery and keys, in polished mahogany cases.

48. The bridge coils to be of 1—10—100 and 10—100—1,000 ohms with reversing arm plug switch.

49. The rheostat coils to be of 1—2—2—5—10—20—20—50—100—200—200—500—1,000—2,000—2,000—5,000 ohms. The coils to be of platinoid, and to be accurate to within one-fifth of 1 per cent.

50. The galvanometer to be of D'Arsonval pointer type, and to have a sensibility of not less than one division, with one Leclanche cell, through 100,000 ohms in circuit.

51. The battery to consist of six chloride of silver cells, with suitable selecting cords admitting of connections to any two in the three sets.

52. The keys to be separate for battery and galvanometer.

53. Connection diagram and direction for use to be on a card on the inside of the lid of the case.

54. Testing generators must be furnished in a varnished hard-wood case and have sufficient capacity to ring through an external resistance of 50,000 ohms. The bells must be fitted inside the case; the binding posts to be outside of the case.

55. The instruments to be supplied with a leather handle on the same side with the binding posts, a crank permanently attached, and a 3-point switch. The top and bottom of the case to be screwed to the sides.

Indicators.

56. A set of steam-engine indicators will consist of two indicators, to be one right-handed and one left-handed, or two right-handed and two left-handed, as directed.

57. Each set to be furnished in one well-finished, strongly made, varnished hard-wood box, with brass hinges and catches, leather strap, lock and key. Each set to be supplied with the following articles: Four springs, scale to be as directed; two attachment valves; one bottle watch oil; one pad of 100 cards for indicator, 4 by 7¼ inches; one screw-driver; one scale rule for each scale of spring; one box pencil leads; two extra hanks of cord; two hooks for cord; two extra drum springs; one book direction for use; necessary wrenches.

Portable Ventilating Sets.

58. To consist of an exhaust fan actuated by an electric motor having a common shaft.

Capacity.

59. Rated horse-power of motor, one quarter; weight of set without box, hose or spare brushes, maximum 90 pounds; normal speed (a maximum deviation of 10 per cent. to be allowed either way), 2,200 revolutions per minute; minimum cubic feet of air delivered per minute, free exhaust, 500; minimum velocity of the air in feet per minute, free exhaust, 4,000.

Dimensions.

60. Height over all to top of oil cup (maximum), 18½ inches; length transversely to shaft (maximum), 18 inches; width with shaft (maximum), 12 inches; width, center line of exhaust case to outer end of motor (maximum), 8⅜ inches; extreme diameter inlet, 5¾ inches; extreme diameter outlet, 4⅜ inches.

Exhauster.

61. To be of centrifugal type.

62. The motor to be on the right-hand side as seen facing the outlet.

63. The base to be extended to properly support the weight of the motor.

64. Handles are to be provided for convenience in handling the set.

Motor.

65. The motor to be series wound for 80 volts, four pole, four field coils; armature to be slotted ring; series wound with the cross connections back of the commutator.

66. The brushes to be carbon, copper plated, end feed at angle to radius.

67. The brush holders to be provided with facilities for adjustment and for securing in proper position.

68. The headboard to have binding posts connecting to the line wires and the junction between the field and armature windings.

69. The construction to be such as will prevent any accidental contact with this connection by line wires.

Heating.

70. The journal is to run cool.

71. The maximum increase of the temperature of the windings of both the field and armature shall not be more than 70° F. over that of the surrounding air, measured by increase of resistance method when run on free inlet and outlet.

72. The motor shall not be ventilated through the fan.

Lubrication.

73. The journal is to be efficiently lubricated by a sight feed oil cup of sufficient capacity for an 8-hour run, which is to be located on the top of the motor frame and connected to the journal by a feed tube.

74. The ends of the support to journal bushing are to be provided with extensions and channels adapted to catch the expended oil and conduct it through a tube to a receptacle at the bottom of the set which is to be provided with a drip cock for emptying as required.

Insulation.

75. No insulating material that can be injured by moisture or a temperature of 200° F. shall be used.

76. All the turns, windings and cross connections to be coated with an approved insulating varnish as wound on or put in place.

77. The completed field coils and armature shall be thoroughly covered, to exclude oil moisture.

78. The insulation resistance between the conductors of the connected machine and frame shall not be less than 1 megohm, measured with not over 1,000 volts before and after test.

79. To be furnished with six extra set brushes, two extra oil-cup glasses, one extra set brush-holder springs, two 25-foot lengths canvas hose fitted with couplings, to attach together or to either the inlet or outlet of the exhauster.

80. To be supplied in a painted, hard-wood, strongly-made, tightly-fitted, screw-fastened box with brass hinges, lock and transporting handles. Chocks to be fitted and secured to keep the set in place when transported. The spare parts to be fitted in separate divisions in upper part of box.

Desk and Bracket Fans.

Desk Fans.

81. Desk fans will be one-twelfth H. P. capacity and wound for 110 volts; the fan to be bladed, and 12 inches diameter.

82. To have a starting and regulating switch in the base and rheostat in the column, giving three speeds at its voltage of about 1,800, 1,400 and 1,000.

83. The bearings to be self-oiling and self-aligning; to operate without throwing or dripping of oil.

84. All outside brass fittings to be polished.

85. The finish, including fan and guard, to be black japanned. The base to be provided with three rubber washers, to deaden vibration and prevent slippage.

86. The armature to be slotted drum. The field and armature to be satisfactorily protected from the access of moisture, oil and dirt. The brushes to be carbon with end feed. The insulation resistance to be not less than 1 megohm, measured with not more than 500 volts.

87. The operation to be with a minimum of noise, friction and vibration.

88. The serial factory number and maker's name to be on a name plate.

89. Each set will be supplied with an extra set of brushes for each fan.

Bracket Fans.

90. Bracket fans are to have a rated capacity of one-sixth H. P., to be wound for 110 volts, and to be fitted with a 4-bladed fan 16 inches in diameter.

91. The specifications for finish, switch and rheostat, bearings, fittings, fan, guard, base, armature, protection of armature and field, brushes, insulation resistance, operation, name plate and spare brushes will be the same as those prescribed for the 12-inch desk fan.

92. The base to be constructed for securing against a bulkhead.

93. The motor and fan to be so mounted that the direction of the air current can be varied. The speeds to be about 1,500, 1,200 and 800.

Rheostats for Motors.

94. To be of four types: (a) Starting; (b) regulating; (c) regulating and reversing; (d) special, to be as directed.

95. All are to be provided with an automatic circuit braker to protect the armature in the case of overload, or failure to open the circuit at the rheostat.

96. Unless otherwise directed: (a) The resistance on the first point shall be such that 80 per cent. of the line voltage shall be dropped in the rheostat with the current of the rated capacity; (b) the device shall open the circuit at 50 per cent. over load.

97. The capacity is to be obtained without paralleling of coils, unless they are capable of carrying the full-line voltage.

98. Starting rheostats shall be capable of carrying safely the full-rated current for 15 seconds.

99. Regulating and reversing rheostats shall be of such resistance and capacity as shall be directed. Reversing rheostats shall reverse the armature current only. Regulating rheostats shall be used in all cases for ventilating sets.

100. The construction throughout shall be fireproof. All springs to be of phosphor-bronze and to carry no current. All slate to be black enameled over the entire surface to prevent absorption of moisture. All windings of cut-out magnet coils to be run through an approved insulating varnish as it is wound on. The outside of the coils to be well varnished and taped. No combustible or absorbent material to be used.

101. The terminals shall be marked with a designing letter or number. The factory number and capacity of the rheostat to be plainly marked. The contact points to be ample in size and well fitted on surfaces.

102. The circuit to be opened by a quick uncontrolled movement for the larger sizes. Where the current is of sufficient power to necessitate it, the makes and breaks shall be made on auxiliary points. When so directetd the entire rheostat and contacts, excepting the lever, shall be enclosed in a water-tight fire-proof case. In this case the lever is to be provided with marks indicating the different positions of control. The insulation resistances to be not less than 1 megohm.

103. All rheostats to be of approved design, construction and operation.

Electric Operators for Steam Whistles and Sirens.

104. To consist of: A valve operated by an electromagnet and also by hand; a clockwork mechanism by which a contact is kept closed automatically for 6 seconds in every minute; a switch by which the valve is controlled from the bridge.

105. The base of the valve chamber is to be a composition casting flanged to 6⅜ inches, to make a flange joint with 2½-inch iron pipe size pipe. The main valve is to be operated by an auxiliary valve, which is in turn operated by the armature of the magnet; the hand-control lever to operate directly on the spindle of the main valve.

106. The lever is to be mounted and supplied with a phosphor-bronze retracting-spring guide pulley, with clamp for securing to the steam pipe. A turned and polished mahogany handle is to be supplied for the chain. The lever and handle are to be provided with shackles for attaching the chain.

107. The magnet is to be placed in a water-tight metal case. The coils shall be multiple wound, so that the self-inductive discharge shall be minimized. A device for absorbing the inductive discharge shall be provided and located at the terminals in the magnet case. The magnet is to be so designed that the maximum increase in temperature over the surrounding air shall not be over 70° F., measured by the electrical method. The wire is to be run through an approved insulating varnish as it is wound on. The exterior of the coils is to be well varnished and covered. The connection to the circuit is to be made in a cable coupling case in which the conduit terminates. The terminals of the coil are to be well secured, and with a considerable length of surface insulation.

108. The clockwork mechanism is to be mounted in a metal case with hinged lock cover. The clockwork is to be an 8-day movement with all parts of non-oxidizable metal. Means are to be provided for the visual indication of the operation of the clockwork and for starting. The contact points to be of platinum and of ample size for extended service without renewal, and to give a double-pole break. A separate double-pole contact device shall be provided in the case, so that the apparatus can be controlled in the chart-house.

109. The controlling switch for the bridge shall be of water-tight construction. To be adapted for mounting on a bulkhead or bridge rail. The movement of the lever to the first point to give a closed circuit for a continuous or at-will blast. The secured point to be in a series with the automatic contact which is operated by the clockwork. Means for retaining the switch on this point are to be provided. The entire mechanism of the controlling switch is to be mounted on one base; the functions of the points to be indicated.

110. The tests will be made for normal operation at 80 volts, and 160 pounds steam. The construction and fixed adjustment shall also be such that the operation shall be efficient and the parts shall withstand, without detriment, an operation at 60 and 100 volts, and 50 and 300 pounds steam and water pressures.

111. All terminals to be marked with a designating letter or number. Each outfit to be supplied with: One set spare springs for clockwork; one extra key for case; ten feet brass flat-link chain for hand operation; one copy instructions for care and operation; one copy of diagram of connections.

112. All to be of approved design, construction and operation.

Annunciators.

113. Annunciators to be of two types: Water-tight and nonwater-tight.

Annunciators (Water-tight).

114. To be of the drop type. Cases to be of composition, polished on the outside. Covers to be made water-tight by flat 2-ply cloth-insertion rubber gaskets, secured by 6-32 F. H. machine screws. Special provision is to be made for clamping down the hinged side in addition to the other sides, the clamping to be effected by swinging screws and butterfly nuts; the ends of the screws to be split and spread to prevent the nut from working loose. The flange is to be flush with the back.

115. The stuffing tubes to be furnished separately, with gaskets, and to be the standards shown in the Bureau's designs.

116. The magnet coils to be wound with single cotton-covered copper-magnet wire, the wire to be run through an approved insulating varnish as it is wound on.

117. The outer surface of coils to be well varnished before being covered.

118. The magnet heads to be of hard rubber.

119. The drop mechanism to be of such design and construction as to effectually prevent the drops from operating when exposed to the motion

of the vessel or external mechanical shock or jar, particularly that of heavy guns.

120. All wooden interior parts to be well soaked in oil, and varnished before being secured in place.

121. The springs to be phosphor-bronze.

122. All interior metal parts to be nickel plated.

123. The drops to be reset by a plunger operating through the bottom of the case through a water-tight stuffing tube.

124. Each annunciator to be provided with a 3-inch water-tight bell of standard pattern.

Annunciators (Nonwater-tight).

125. Cases to be of solid polished mahogany. All interior wooden surfaces to be oiled and varnished.

126. The drop mechanism and magnet coils to be the same as that specified for annunciators, water-tight.

127. Each to be provided with one iron-box buzzer of standard pattern.

128. Annunciators for fire alarms will have in addition a separate board with push connections for making or breaking each circuit running to the board.

129. Large annunciators will be provided with a ledge underneath the outer hinged part to support the weight when open.

BELLS.

130. Bells to be water-tight or nonwater-tight as directed, and of two kinds: Vibrating bells; single-stroke bells.

131. All bells directed to be water-tight must conform strictly to the Bureau's designs; the sizes to be designated by the diameter of the gong.

Vibrating Bells.

132. Water-tight vibrating bells are to be in two sizes, 3-inch and 6-inch, as may be required.

133. Nonwater-tight vibrating bells to be of commercial iron-box type; to be in two sizes, 2½ inches and 5 inches, as may be required; the cover to be secured by a lug fitting under a recess on the gong side, and a snap spring on the opposite side; the spring and lug to insure that the cover will not fall off under mechanical shock or jar. To have pivoted armature and non-turning binding posts; to ring easily on one Leclanche cell and be adjustable to ring on an increased number of cells.

Single-stroke Bells.

134. Water-tight single-stroke bells to be 6-inch, and of same pattern as the water-tight vibrating bell.

135. Nonwater-tight single-stroke bells to be of commercial iron-box 5-inch type, and of the same pattern as the nonwater-tight vibrating bell; to have non-turning binding posts and ring easily on one Leclanche cell and be adjustable to ring on an increased number of cells.

Buzzers.

136. Buzzers to be water-tight and nonwater-tight, as directed.

137. Water-tight buzzers will conform strictly to the Bureau's design,

all contacts to be of platinum. Bosses for screws to be flush with the back of the case. All wire of windings to be run through an approved insulating varnish as it is wound on; the windings to be varnished before covering is put on. Joints to be rosin soldered and taped.

138. Nonwater-tight buzzers are to be of the iron-box type; the case, mechanism and cover to conform to the specifications for the 2½-inch water-tight bell. All contacts to be of platinum. The outside of the coils to be well varnished or shellaced before covering.

139. All buzzers to ring easily on one Leclanche cell and be adjustable to ring on an increased number of cells.

Ceiling Buttons.

140. Ceiling buttons to be of commercial porcelain type, 1½ inch in diameter.

141. The interior of the base to be conical, to have a central hole for the wire lead not less than five-sixteenths of an inch in diameter; to be provided with two screw holes for securing to the woodwork, and two scores in the rim for leading in the wires.

Thermostats.

142. Thermostats will be of the mercurial type; the mercury to be strained and pure.

143. The contact to be made in an enclosed air-tight chamber.

144. The increase of temperature necessary for efficient operation must have no detrimental effect on the efficiency, operation or construction of the device.

145. To be non-adjustable; the insulating material to be of such a nature or so treated as to prevent the absorption of moisture, in order to prevent grounding or short-circuiting.

146. The chamber to be arched in its upper part in order that the mercury may have free access to the contact point; the chamber surrounding the contact point to be of a reduced cross section.

147. The supporting and containing flange to be as light as possible and to touch in three small surfaces only, so that there may be a minimum conduction of heat from the mercury. The diameter of the flange to be 1⅞ inch, with two five thirty-seconds inch holes on a diameter; distance to be 1½ inch center to center. The body to be not over $1\frac{1}{16}$ inch diameter, and 1⅛ inch high over head of screw.

148. Thermostats are to be tested by suspending them in dry air, steam-coil heated. They must close the circuit at not less than 200° nor more than 220° F., and not require more than ten minutes to do so.

Telegraphs and Indicators.

149. The connecting points for all telegraphs and indicators are to be distinctly marked with a designating number, to facilitate connections and avoid danger of burning out.

Engine Revolution-order Telegraphs.

150. Engine revolution-order telegraphs are to be as compact as possible, that they may be installed in conning towers.

151. The part of the device intended for use on the bridge (or in chart-house or conning tower) to consist of a transmitter and reply receiver; the scale to indicate each revolution, unless otherwise directed, and be capable of indicating each individual point of the scale within the assigned limits.

152. The motion of the handle or lever is to be in the same direction as the desired motion of the vessel unless impracticable from the principle of operation of the instrument; any motion of the handle in either direction must operate a distinctly audible signal in the engine-room.

153. The construction of the instrument to be such that it can be mountetd on a column. In twin-screw vessels it is very desirable that the instruments for both engine-rooms shall be combined in order to secure convenience of operation and simultaneous transmission to both engines.

154. The instruments that are to be placed in the engine-room to consist of a receiver and a reply transmitter, the dials to correspond to those of the instruments on deck.

155. The direction of the motion of the handle or lever of the reply transmitter to be in the same direction as the motion of the vessel indicated by the deck order, unless impracticable from the principle of operation of the instrument.

156. The construction of the instrument to be adapted for mounting on bulkheads; in twin-screw vessels to be mounted on the longitudinal bulkhead.

157. All transmitters, reply transmitters, receivers or reply receivers must be thoroughly water-tight; their dials to be illuminated by standard instrument lamps; the handles or levers to be capable of being secured or removed when the instruments are not in use.

158. The design of engine revolution-order telegraph devices must be such that they will operate efficiently irrespective of ordinary variations of circuit potential.

159. All engine revolution-order telegraphs, connections and instruments to be of approved design, construction and operation.

Helm-order Telegraphs.

160. Helm-order telegraphs are to be of the simplest possible construction; to be of such material and construction as to be unaffected by moisture and capable of being operated on deck in any weather. They are to be adapted for mounting on a pedestal or a bulkhead as may be required. The actuating force is to be of sufficient magnitude to prevent inaccuracy of indication from ordinary changes in contact resistances. The dials to be direct reading to the extent of showing all convenient and necessary angles of helm for tactical use. The dials to be water-tight; the mechanism to be so constructed that the indications will not be materially affected by ordinary fluctuations of circuit potential; the dials to be illuminated by standard instrument lamps.

161. The movement of the handle, lever or pointer to correspond to the direction of the movement of the helm ordered. The device to be operated by either the dynamo or transformer current, tapped from resistance plates.

162. All helm-order telegraphs, connections and instruments to be of approved design, construction and operation.

Engine-revolution and Direction Indicator.

163. The transmitter to comprise in its design, construction and operation the following features: (a) To be of the simplest possible construction; (b) to be capable of operating for extended periods with minimum attention or repair; (c) to be unaffected by moisture; (d) to be adapted for mounting on a bulkhead, or pedestal, or overhead, as required; (e) to be actuated from the shaft by a simple device; (f) to be provided with ready and simple means of adjusting its power to compensate for any change in the value of that power; (g) to be able to operate so that the pointers of the indicators will give an indication corresponding to the exact value of the number of revolutions from zero to the assigned maximum, and be entirely free from oscillation; (h) the design to be such that the value of the indications shall not be appreciably changed in any one of the indicators, should any number of the remainder be cut out of circuit.

Indicators.

164. The indicators for the bridge to be adapted for mounting singly on pedestals with the dials facing each other, unless otherwise directed. For other stations they shall be adapted for mounting on bulkheads. The scale is to be uniformly graduated, over its entire length, by single revolutions. The zero and every ten points to be marked in plain figures. The maximum number of revolutions to be as directed. The scales to be illuminated for night service by the standard instrument lamp in water-tight case. The pointer should move in the direction which the motion of the shaft will tend to move the ship. The direction of revolution, whether ahead or backing, is to be plainly marked on the respective sides of the scale. To be of water-tight construction.

165. The actuating force to be of sufficient magnitude to prevent inaccuracy of indications from ordinary changes in contact resistances.

166. All engine-revolution and direction indicators are to be of approved design, construction and operation.

Helm-angle Indicators.

167. The design, construction and operation of helm-angle indicators must comprise the following features: (a) Simplicity; (b) certainty of contact and action; (c) freedom from injury from moisture; (d) a minimum of attention and repair; (e) constancy of adjustment.

168. The actuating force is to be of sufficient magnitude to prevent inaccuracy of indications from ordinary variation of contact resistance or circuit potential.

169. The operation will include the indication in the same dial of the

angle of the tiller with the keel, and its direction, starboard or port, and be capable of operating a number of dials on the circuit. The dials to be direct reading to the extent of showing all convenient and necessary angles of helm for tactical use. The dials to be water-tight; the mechanism to be so constructed that the indications will not be materially affected by ordinary fluctuations of circuit potential; the dials to be illuminated by standard instrument lamps.

170. The transmitter is to be operated as directly from the rudderhead as practicable.

171. Helm indicators to be operated by dynamo or transformer current. When rheostats are used the connections will not be made to the end binding posts, but through a resistance, to protect the circuit from the full-dynamo potential.

172. All helm-angle indicators, connections and instruments to be of approved design, construction and operation.

TELEPHONES.

Telephones for Conning Towers.

173. Unless otherwise directed, the construction will be as follows:

174. All parts excepting the receiver to be enclosed in a water-tight bronze case. The case to be in two parts; one part to be swung on vertical hinges. The weight to be taken normally by ledges on the bottom. The joint between the parts to be made water-tight by a flat gasket. The working mechanism to be attached to the swinging part of the case, and disposed as follows:

175. The annunciator drop mechanism is to be placed at the top, and to be made in accordance with the specifications for water-tight annunciators, which will be marked as directed. The front of the case, over the bell, to be covered with gauze or perforated sheet brass to effectively transmit the sound. The base part to be surrounded by a flange flush with the back; the edge to be raised to a height sufficient to take the size of tube required for the conductors.

176. The bell to be 3 inches in diameter, of water-tight construction, and surrounded by a water-tight covering on the side, inside the case. The push button is to be of standard water-tight construction. The contacts of both bell and push-button to be of platinum.

177. The transmitter is to be of the solid-black type, operated with battery current, and without the use of an induction coil.

178. The switches are to be so connected that only the station to be communicated with is in circuit at the time, in order to avoid interference.

179. The switches are to be marked as directed, and in the same order as the drops of the annunciator. The openings for the plungers of the switches are to be practically water-tight.

180. The receiver is to be of the watch-case type; the case to be of bronze and hard, black rubber.

181. The cords for the receiver and the plunger of the automatic switch are to be led through the bottom of the case in standard stuffing tubes.

182. All terminals are to be marked with a designing letter or number.

Water-tight Telephones.

183. The water-tight telephones, for use in stations connected with the conning tower, are to be constructed as follows:

184. The transmitter is to be of the solid-black type, operated with battery current, and without the use of an induction coil. To be contained in a bronze case, pivoted back of the center of gravity, so that when the receiver is pushed into the spring clips, which are spaced around the mouthpiece, the added weight will cause them to drop and permit the mouth of the receiver to hang down. The cutting out of the transmitter to be accomplished automatically by this movement.

185. The spring clips are to be of ample strength for securing the receiver when the apparatus is subjected to severe shock or jar. The trunnions of the transmitter are to be supported by bronze arms, extending fom the part of the case containing the bell, push-button and terminals.

186. The cover of the case is to be of metal, packed water-tight by a flat rubber gasket, and secured by machine screws. The terminals are to be on the inside of the case, and are to be machine screws tapped into the metal with washers, or of the binding-post type.

187. Lugs are to be run out from the sides of the case for attaching the instrument to bulkheads with three-eighths inch standard bolts.

188. The terminals to be stamped with a designating number or letter.

189. The receiver is to be of the watch-case type; the case to be of bronze and hard black rubber. The receiver cord to be run out of the interior of the case through a navy-standard box tube. Facility is to be provided in the disposition of the interior parts for running into the case at either the sides or the bottom, with the conduit, or stuffing tubes used with molding, as may be required for the location in which the instrument is installed. The covering of the cord is to be treated with an insulating varnish, to prevent the absorption of moisture. To be provided with a name-plate, marked for the name of the station with which it is connected.

Nonwater-tight Telephones.

190. Nonwater-tight telephones are for use in the captain's stateroom and the chart-house. The transmitters are to be of the solid-back type, operated by a battery, without induction coil. The receivers are to be of the watch-case magneto type, the containing case to be of bronze and hard, black rubber. The receiver cords are to be provided with a means of relieving the strains from the ends attached to the case, in order to prevent breakage of the conductors. The braids are to be treated with a non-absorbent compound.

191. The bells are to be of the vibrating type, with 3-inch gongs, to be operated by battery current. The push-button to be of standard water-tight construction. The contacts of the bell and push-button to be of platinum. The terminals are to be inside of the case; to be of the binding-post type, or machine screws with washers tapped into the metal; to be marked with a designating number. To be provided with a name-plate, marked for the name of the station with which it is connected.

Transformers.

192. To be of the rotary direct-current type, transforming from 80 volts to 20, 13.3, and 6.6 volts. The secondary ampere capacity to be not less than 4.

193. The insulation of commutators to be mica throughout.

194. The brush-holders to be provided with stops so that the position of the brushes cannot be misplaced more than the arc corresponding to one commutator bar.

195. The wire of all windings to be run through an approved insulating varnish as it is wound on. The exterior of the coils to be well coated with varnish.

196. The spool windings to be protected from chafe or mechanical injury.

197. The insulation resistances to be not less than 1 meghom, measured hot, with 500 volts.

198. The maximum heating of the windings over the surrounding air to be not over 80° F. in the armature and 60° F. in the shunt, with full-rated load. All insulating material of absorbent nature, used in the construction, shall be so treated as to effectually prevent injury from the effects of moisture or air.

199. The journals to be provided with ring oilers.

200. The balance of rotating parts to be such that there will be no perceptible vibration.

201. Each machine to be provided with one fire-proof starting rheostat of not less than 30 or more than 50 ohms cold resistance.

202. All parts made of slate to be black enameled on all surfaces.

203. The following strictly interchangeable spare parts are to be provided with each transformer: One armature; one set of brushes, 6 total, 3 by ⅜ by ¼ inch; one set of brush-holder springs, 6 total.

204. The external dimensions of transformers shall approximate the following: Height over poles, 11 inches; width over terminals, 10 inches; length with shaft, 16 inches. The weight, not including spare parts, not to exceed 80 pounds.

205. The data as to gauge, character and thickness of insulation, and total weights of each size of wire used in the windings is to be furnished with each transformer.

General Alarm Gongs.

206. To be single stroke, 12 inches in diameter.

207. To operate efficiently with from 20 to 15 volts at terminals.

208. Resistance to be not over 52½ or under 47½ ohms, and to take not over one-half ampere at 20 volts.

209. The adjusting spring to be of phosphor-bronze and operated from the outside of the base.

210. The base to be of the best mahogany, in two parts; one for attachment to the bulkhead, to be not less than three-fourths of an inch thick; the other to be not less than one-half of an inch thick at back.

211. The side of the base opposite the striker to be stamped "Top," and both parts marked with a serial number on each side of the joint.

212. Brass screws only to be used for holding together.

213. The two coils of the magnet to be thoroughly insulated from the cores. The insulation resistance to be not less than 1 megohm, measured with not less than 100 volts. The magnet heads to be hard rubber. The winding to be of single cotton-covered copper wire, to be run through an approved insulating varnish as it is wound on. The exterior of the coils to be wrapped with insulating tape laid closely, varnished and secured to effectually prevent access of moisture.

214. The connections between coils to be rosin soldered, taped, and varnished. The leads from magnets to binding posts to be made with standard No. 14 B. & S. G. conductor.

215. The binding posts to be inside of outer base part, one on each side, and to make the connections between magnet and circuit under washers by screw nut.

Rheostats for Tapping Lighting Current at Reduced Voltage for Interior-Communication Circuits.

216. Shall be of the enamel type. The capacity to be such that the maximum heating of the surface shall not be over 70° F. in excess of that of the surrounding air. The taps shall be taken from between two equal portions of the resistance, the value of each being not less than one-fourth of the total, so that the circuit may not be exposed to the full-line voltage in the case of grounds. The terminals to be marked with a designating number or letter. The rheostat to be marked on a name plate with the title of the circuit which it supplies. The factory number is to be also plainly marked. The resistances, size and number of the plates to be as directed.

Search-light Projectors.

217. They will be designated as follows: First, by the type, as hand controlled, electric controlled. Second, by the diameter of the mirror, as 18-inch, 24-inch, 30-inch.

Hand-control Projector.

218. It shall, in general, consist of a fixed pedestal or base, surmounted by a turntable carrying a drum. The base shall contain the turning mechanism and the electric connections, and be so arranged that it can be bolted securely to a deck or platform.

219. The turntable to be so designed that it can be revolved in a horizontal plane freely and indefinitely in either direction, both regularly and gradually by means of suitable gearing, and rapidly by hand; the gearing being thrown out of action.

220. The drum to be trunnioned on two arms bolted to the turntable, so as to have a free movement in a vertical plane, and to contain the lamp and reflecting mirror. The drum to be rotated on its trunnions, both regularly and gradually by means of suitable gearing, and rapidly by hand; the gearing being thrown out of action. The axis of the drum to

be capable of a movement of not less than 70° above and 30° below the horizontal.

221. The drum to be thoroughly ventilated and well-balanced; to be fitted with peep sights for observing the arc in two planes, and with hand-holes to give access to the lamp. It must be so designed that either a Mangin or a parabolic mirror can be used, and a means for balancing it with either mirror must be provided.

222. The mirror to be made of glass of the best quality, free from flaws and holes, and having its surfaces ground to exact dimensions, perfectly smooth and highly polished. Its back to be silvered in the most durable manner; the silvering to be unaffected by heat. To be mounted in a separate metal frame lined with a non-conducting material, in such a manner as to allow for expansion due to heat and to prevent injury to it from concussion.

223. The lamp to be of the horizontal carbon type, and designed for both hand and automatic feed. The feeding of the carbons must be effected by a positive mechanical action, and not by springs or gravitation. It must burn quietly and steadily on an 80-volt circuit in series with a regulating rheostat, and shall be capable of burning for about six hours without removing the carbons.

224. The front of the drum to be provided with two glass doors, one composed of strips of clear plate glass, and the other of strips of plano-concave glass lenses, so designed as to give the beam of light projected from the mirror a horizontal divergence of at least 20°. The doors to be interchangeable, and to be so arranged that either can be put in place on the drum easily and quickly.

Electrically-controlled Projector.

225. To be in all respects similar to the hand controlled, with the addition of two shunt motors, each with a train of gears; one motor for giving the vertical and the other the horizontal movement of the projector. The motors and gears to be contained in the fixed base, and to be well protected from moisture and mechanical injury. A means to be provided for quickly throwing out or in the motor gears, so that the projector can be operated either by hand or by motor, as desired.

226. The motors to be operated by means of a compact, light and water-tight controller, which can be located in any desired position away from the projector. The design of the controller to be such that the movement of a single handle or lever, in the direction it is wished to cause the beam of light to move, will cause the current to flow through the proper motor in the proper direction to produce such movement. The rapidity of the movement of the projector to be governed by the extent of the throw of the handle or lever. A suitable device to be included whereby the movement of the projector can be instantly arrested when so desired.

227. All projectors to be finished in a dead-black color throughout, excepting the working parts, which shall be bright.

228. The general dimensions of projectors to be within the following limits:

Dimensions.	Diameter of base.	Height of centre of mirror.	Weight complete.
	Inches.	Inches.	Pounds.
18-inch hand controlled	22	46	425
18-inch electrically controlled	22	46	600
24-inch hand controlled	24	56	725
24-inch electrically controlled	24	56	875
30-inch hand controlled	26	58	925
30-inch electrically controlled	26	58	1,075

229. The lamps to be designed to produce the best results when taking current as follows: 18-inch, 30 to 35 amperes; 24-inch, 50 to 60 amperes; 30-inch, 75 to 90 amperes.

230. The 18-inch projector shall project a beam of light of sufficient intensity to render plainly discernible, on a clear, dark night, a light-colored object 10 by 20 feet in size, at a distance of not less than 4,000 yards; the 24-inch projector, at a distance of not less than 5,000 yards; and the 30-inch projector at a distance of not less than 6,000 yards.

Installing Electric Plants and Electrical Means of Interior Communication on Board Ships of the United States Navy.

ELECTRIC PLANTS.

Conduit and Molding.

1. *Conduit* will be used for all spaces in the water-tight system. It is to be preferred for use in all other locations; but in spaces where it may not be desirable to run it over woodwork, as in chart-house, emergency cabins and officers' quarters, standard wooden molding may be used.

2. It will be fastened to the metal of the ship by stout metal straps at such intervals as will firmly secure it in place, prevent undue vibration, and withstand any unusual strain to which it may be subject.

3. It shall be continuous and to be made water-tight at bulkheads by approved flanges and stuffing boxes.

4. Leads through armor will be made by tapping in on both sides; continuity to be secured by smooth turning the end of one of the conduits, to a depth of the thread, for a length equal to the untapped thickness of the armor; the ends to butt together.

5. Connections to standard junction boxes, switches and receptacles to be made by tapping into a boss on a plate to be screwed to the box. A

box of cast metal with bosses for tapping in, and fitted with standard interior fittings and covers, may be used instead of standard boxes. Flanged feet to be provided in each case for screwing the appliance in place, the flange to set the box clear of the metal of the ship.

6. Both positive and negative legs of the same circuit will be led in the same conduit for all conductors of and below 30,856 cm.; all conductors above 30,856 cm. to have a conduit for each leg. A clearance of not less than three-sixteenths of an inch to be allowed for drawing in and out. When double conductor plain is to be used, a clearance of not less than one-eighth of an inch is to be allowed.

Molding.

7. The backing strip, laid in advance, will be secured by brass machine screws (No. 14-20) placed alternately on the sides, and so spaced (about 12 inches apart) that no screws will come under junction boxes, switches or receptacles; the screw heads being countersunk.

8. *Molding* to be secured in place through center wall with brass wood screws (No. 8-1½ inches). Screws to be placed, as directed, at intervals not greater than 12 inches; the screw-heads being countersunk.

9. *Molding* to be finished in the same manner as the surrounding woodwork, and all molding and backing except hard wood shall be thoroughly coated with white-lead paint after being fitted and before being secured in place. All molding to be capped, the capping being secured to the side walls by round-head brass screws placed not more than 12 inches apart.

10. In running the *backing strip*, a path that will clear usual sized bolt heads and other projections will be chosen. To avoid such obstacles, small detours from a direct lead will be allowed.

11. The part of the *molding* under the wire gutters is never to be reduced in thickness below three-eights of an inch.

12. Junction boxes, switches and receptacles (combined or separate) will be separated from metal surfaces by at least three-quarters of an inch of wood, and secured with brass wood screws entering the wood for one-half of an inch. *It is required that at least one-quarter of an inch of clear solid wood shall separate all wiring accessories from the metal of the vessel.*

13. The junction boxes, switches and receptacles being wider than the backing strip, the latter will always be built out to bring it flush with their sides, except where a number of moldings are grouped together, as in passageways where feeders are run; then these boxes can be let into adjacent moldings (never more than three-sixteenths of an inch), and so disposed that no two in adjacent moldings will be abreast. *They are never to be located over screws securing the backing in place.*

14. Controlling switches, feeder junction boxes and distribution boxes are to be placed with especial reference to convenience of access.

15. Where several leads of molding run side by side, a backing strip of the required thickness in one width may be used under all.

Wiring.

16. The two-wire system to be used.

17. All wire to be that prescribed by the specifications for standard insulated wire supplies.

18. All wires to be run where directed and where accessible; those for circuits used in action to be kept below the water-line as much as possible.

19. Thorough water-tightness is to be observed for all leads into wiring appliances and fixtures, and through all bulkheads and decks.

20. The outer tape and braid on the ends of all conductors on lighting circuits, where such conductors are connected in fixtures and wiring appliances, is to be removed, exposing the vulcanized rubber underneath to within one-eighth of an inch of the outside of the gland.

21. Special care must be observed in every instance not to cut into or otherwise injure the vulcanized rubber.

22. When the tape and braid is removed for connecting up movable fixtures, the braid ends shall be protected from fraying by whipping the end of the braid and varnishing.

23. All wire run through decks or bulkheads, where molding is used, must be led through standard stuffing tubes; when running through beams or bulkheads, and water-tightness is not required, the hole for the lead must be bushed with hard rubber, the hard rubber extending into the molding on each side.

24. No feeders or mains to be led overhead in locations subject to heat, or through or into coal bunkers, unless specially authorized.

Circuits.

25. The circuits will be divided into two classes:

1. Lighting circuits.
2. Motor circuits.

Lighting Circuits.

26. Lighting circuits will comprise the following divisions, according to the service required:

First. *Continual service*, to include lights at or in (and to supply energy for operating portable ventilating sets)—

Passages.	Ventilating fans.
Fire pumps.	Motors.
Bilge pumps.	Inner-bottom manholes.
Hand pumps.	Auxiliary condensers.
Ash hoists (lower).	Auxiliary boilers.
Bunkers.	Dynamo-room.
Workshops (lower).	

Second. *Battle service*, to include lights at or in (and to supply energy for operating smoke fans, instruments, and firing apparatus on dynamo circuit)—

All guns.	Conning tower.
Ammunition-handling rooms.	Central station.
Magazine light boxes.	Armory.
Shell-room light boxes.	Range-finder.
Ammunition-room light boxes.	Military tops.
Ammunition hoists.	Hydraulic rooms.
Turret turning gear.	Instruments.
Torpedo compressors, racks and tubes.	Signal tower.

Third. *General service*, but not in action (and to supply energy for operating bracket and desk fans)—

Chart-house.
Officers' quarters.
Petty officers' quarters.
Offices.
Galleys.
Dispensary.
Sick bay.
Standing lights.
Drying-rooms.
Winches and cranes.
Issuing-rooms.
Distiller.
Workshops (upper).
Diving lamps.
Closets.
Washrooms.
Lavatories.
Heaters.
Side ladders.
Propeller booms.
Military masts (inside).
Ground tackle.

Fourth. *Sea service*, to include lights at or in (and to supply energy for operating instruments)—

Engine-rooms.
Fire-rooms.
Steering-rooms.
Steering wheels.
Forced draught.
Chart table.
Shaft passages.
Instruments.

Fifth. *Day service*, extinguished at 9 P. M., to include lights in (and those on the top or sides of superstructure and deck houses)—

Hammock spaces.
Holds.
Steerage country.
Storerooms.
Mess-rooms.

Sixth. *Special service*, to include—

Signal lights.
Projectors.

27. Lights in compartments and their adjoining compartments which have the same kind of service (as outlined under the separate divisions of *general*, *sea* and *day* service) to be grouped on the same mains and controlled by a switch in a convenient location.

28. The maximum load for all lighting feeders, excepting those for search-lights, shall not exceed 75 amperes.

29. In case the current required for any service exceeds 75 amperes, a sufficient number of separate feeders shall be provided. Feeders will be numbered and designated by the terms *forward* and *aft*, by decks or specific compartments, and further divided into *starboard* and *port*, as may be required.

30. Lights under the division *sea service* will be on the mains fed by the feeders for *continual service*; those for *day service* will be on the mains fed by the feeders for *generel service*.

31. Lights on mains fed by feeders for *battle service* to supplement those on feeders for *continual service*.

32. A *signal circuit* shall be provided to include and feed the double truck lights, night signalling sets, binnacle lights; and outlets for running lights, top-lights, stay and stern lights, and for signal use.

33. The signal circuit shall be fed by separate feeders leading directly from the dynamo-room switchboard, to connect by transfer switches to

adjacent feeders of the battle service; the transfer switches to be located in the chart-house.

34. The *search-lights* shall be fed by separate circuits, each leading from the dynamo-room switchboard through a rheostat, ammeter, and D. P. automatic circuit-breaking device; to be placed in vertical lines on separate instrument boards.

35. The circuit-breaking device to be of approved design, construction and operation; and to have a capacity of and be capable of being adjusted to a current of 50 per cent. in excess of the normal working current of the lamp in circuit. Each circuit shall have its own voltmeter.

36. A rheostat in a non-combustible frame shall be supplied and fitted in the dynamo-room for each search-light. The rheostat to have a dead resistance equivalent to a drop of 20 volts for the normal current at which the lamp operates, and also an adjustible portion, in not less than ten divisions, to give a drop of 10 volts for the normal current of the lamp; the resistance to be measured hot. The rheostat to be of approved design, construction and operation. The rheostats will be marked "high" and "low" to indicate the movement of the handle for increased or decreased current.

37. Search-light circuits shall have no connection with the circuits for incandescent lights, except as provided for on the switchboard.

38. Each search-light circuit shall lead to its own pedestal, where it will terminate in an approved water-tight receptacle, the pedestal to be located as directed.

39. The area of cross section of search-light feeders shall be on the basis of at least 500 circular mils per ampere at full load.

40. Controller receptacles for each electrically controlled search-light will be installed at locations convenient for the operation of the controller; the pressure wire for the motors to be connected to the adjacent transfer circuit.

Motor Circuits.

41. Each motor circuit shall be connected to the dynamo-room switchboard by a D. P. automatic circuit-breaking device of approved design, construction and operation; to have a capacity of, and be capable of being adjusted to, a current 50 per cent. in excess of the normal rated load of the circuit.

42. Each motor of and above 4 K. W. will have a separate feeder leading from the dynamo-room switchboard.

43. Motors below 4 K. W. will be supplied by the same feeders, the maximum load on any one feeder not to exceed 75 amperes; in case the current required exceeds 75 amperes, a sufficient number of feeders shall be provided. Motors which are located in spaces above the protective deck and not protected by armor, and which are on the same circuit with protected motors, will have a cut-out switch in their mains, so that any damage to the unprotected portion of the circuit will not affect the remainder.

44. When more than one motor is fed by the same feeder the main leading to each motor shall have in circuit an automatic circuit-breaking

device, either included in or separated from the controller, which shall open the circuit both in case of failure of the line voltage and 50 per cent. overload.

45. If not included in the controller the automatic device will be located conveniently near it.

46. The controller and automatic circuit-breaking device to be of approved design, construction and operation.

Feeders and Mains on Lighting Circuits.

47. The area of cross section of the feeders and mains on the lighting circuit shall be such that the fall in potential from the dynamo terminals to the most distant outlet shall not be more than 3 per cent. at the normal load of the feeder. The size of feeders or mains to be the same throughout their entire length; no "tapering" to be permitted.

48. There shall be no soldered or other joints in feeders or mains except those made in the standard appliances.

49. No feeder or main will have a less area of cross section than 1,000 circular mils per ampere at the normal load, to be reckoned at the rate of nine-tenths ampere per lamp of 16-candle power.

50. The feeders shall be controlled by switches and fuses on the switchboard.

51. Mains which tap into feeders may be arranged in loops for the purpose of equalizing drops; submains shall tap into mains only, with branches leading to the outlets.

52. No wiring appliance other than switches and feeder junction boxes are to be placed on feeders.

53. Wherever mains are led off from feeders it shall be done through standard feeder junction boxes, having double pole fuses of standard pattern, which shall blow on the basis of 1 ampere per 500 circular mils of the main.

54. Not more than two feeders shall ever be interconnected, and no feeders shall be interconnected through their mains.

55. Feeders which interconnect shall have an area of cross section of not less than 1,500 circular mils per ampere at the normal load.

56. Feeders for *continual service* and *battle service* are to be interconnected for their own division of service. Mains for any division of service are to be interconnected either to their adjacent mains or to those of the deck next above, but not more than two mains shall be so interconnected. Interconnected mains shall have an area of cross section of 1,500 circular mils per ampere at normal load.

57. All mains and submains are to be made controllable by switches, placed near the junction boxes.

58. All outlets shall be fed from the mains by branch wires, which shall be an unbroken continuation from junction box to outlet, except when specially authorized.

59. The wire used for branch circuits shall be the standard No. 14 B. & S. G. Leads from distribution boxes to single outlets may be run with double conductor plain.

60. When molding is used, each outlet on *continual*, *battle* and *sea* service shall have a separate three-way branch junction box; four-way branch junction boxes may be used in this case for outlets on general or *day* service.

61. In offices and staterooms, two outlets, one for desk light, the other for desk fan, may be installed on the same branch circuit.

62. Fuses for branch junction boxes to be for the normal rated load of 4 amperes, and to blow at 8 amperes. Fuses for feeders and mains to be at the rate of 1 ampere per 1,000 circular mils, and to blow on the basis of 1 ampere per 500 circular mils.

63. No individual switches shall be placed on branches of *continual service* or *battle service*. The lights on the branch circuits for these services shall be controlled by a group switch, except for those to be used as standing lights.

Feeders and Mains on Motor Circuits.

64. The area of cross section of the feeders, on circuits for motors of and above 4 K. W. shall be such that the fall in potential from the dynamo terminals to the motor terminals shall not be more than 5 per cent. at the normal load of the feeder; for other motor feeders to be as prescribed for lighting feeders. Whenever possible, the feeders for motors of and above 4 K. W. shall be an unbroken continuation form the switchboard to the controller contacts.

65. Wherever mains are led off from feeders it shall be done through standard feeder junction boxes, having double pole fuses of standard pattern, which shall blow on the basis of double the normal load of the motor.

Permanent and Movable Fixtures.

66. Silver-plated fixtures to be used in cabins, wardroom and junior officers' quarters only. Bronze fixtures to be used in offices, and quarters assigned to warrant officers and chief petty officers.

Permanent Fixtures.

67. *C. F. No. 1*, *C. F. No. 3* and *Commercial C. F.* to be used in cabins and wardroom only.

68. *C. F. No. 2* to be used for general overhead lighting in passages, crew spaces and chart-houses on *day service*, and quarters for warrant and chief petty officers. For other spaces the *steam-tight* fixture is to be preferred for overhead lighting, and to be fitted with guard wherever the globe is liable to breakage.

69. If lighting is desirable on both sides of a bulkhead, it will be provided by separate lights.

70. *Bunker* lights are to be installed overhead between the frames in which each of the coal chutes are placed; a light to be installed on the bunker bulkhead conveniently near the doors leading to the fireroom, that the part of the bunker in the vicinity of the door may be lighted.

71. *Bulkhead* fixture to be used for standing lights for all locations except quarters and offices. It is not to be used for overhead lighting

except in those locations where the *steam-tight fixture* would allow insufficient head room, and where a guarded fixture is required.

72. *Brackets* are the standard fixtures for side lighting for quarters and offices.

73. *Steam-tight* fixtures, in addition to the use prescribed under C. F. No. 2, shall be fitted as required to thoroughly light the lubricators under engine cylinders and steam chests.

74. Whenever possible, the conduit leads to the cylinder and steam-chest lights shall be from overhead to avoid the effect of vibration.

75. *Double truck* lights are to be installed on the fore and main masts of vessels having two or more masts.

76. Single-masted vessels to have a double truck light on the mast. Torpedo-boats and vessels of special design will not be fitted with double truck lights unless specially authorized. Double truck lights are to be furnished with, and connected to, two lengths of double conductor plain and two receptacle plugs; the length of conductor to be that best adapted for connection to the receptacles; the receptacles to be without switches and located, in case of use with topmasts, on the bibbs or athwartship brackets of the military top; in the case of pole masts the receptacles will be located under the upper deck in which the mast partners.

77. Leads from the controller to the receptacles will be the standard No. 14 B. & S. G. conductor, and will be run as best adapted for the particular vessel.

78. The controller shall be in strict conformity with the Bureau's designs.

79. *Binnacle light* to be connected to a branch junction box on the signal circuit by a suitable length of double conductor plain, led through the pedestal to the plunger contacts.

Movable Fixtures.

80. Desk lights will be furnished with, and connected to, a length of double conductor, silk, and an attachment plug; the length of conductor will be that best adapted to the location, but in no case to be less than 15 feet.

81. Not less than two hooks for suspending the shade holder of the desk light will be installed; to be conveniently located for use.

82. Four cup hooks, two on the ceiling and two on the bulkhead, will be placed in locations convenient for suspension of the bight of the conductor.

83. All the foregoing hooks to be of the same finish as the fixture.

84. *Running lights, towing* and *top-lights* will be furnished with, and connected to, two lengths of double conductor plain and two receptacle plugs; the lengths of conductor to be that best adapted for connection with the receptacles.

85. Receptacles for the foregoing lights are to be placed conveniently near the lights and to be without switches. The junction boxes to be easily accessible for replacing and inspecting fuses.

86. *Magazine lanterns* will be furnished with, and connected to, two

lengths of double conductor plain and two receptacle plugs; the length of conductor to be that best adapted for connection with the switch and receptacles.

87. The two switch-and-receptacle or receptacle boxes to be installed on a wooden block fitted in the recess of the light box; the conduit to extend to, and tap into the sides of, the light box. All conduit inside the magazine or light box must be of brass.

88. *Signal lanterns* to be furnished with, and connected to, a length of double conductor plain and a receptacle plug; the length of conductor to be that which is required for the especial use.

89. Unless otherwise directed, 3 red, 4 white and 2 green signal lanterns will be provided for each vessel.

90. *Deck lanterns* and *portables* will be furnished with, and connected to, a length of double conductor plain and a receptacle plug. One-half the number allowed shall have a length of conductor of 25 feet, one-fourth a length of 50 feet, and the remaining one-fourth a length of 100 feet.

91. Special care must be exercised in connecting to the socket of the portable, to prevent grounding of the outer conductor.

92. Outlets for portables are to be provided at the manholes for the inner bottoms, and where required to facilitate the inspection and operation of machinery. They are also to be provided at such convenient places as the use of the fixture may suggest and where necessary to afford lighting for repair work on the vessel.

93. *Battle lanterns* to be furnished with, and connected to, a length of double conductor plain and a receptacle plug; the length of conductor to be that best adapted for use in the particular locality.

94. Switch and receptacle for battle lanterns are to be provided on the battle-service circuit in military tops, conning towers, gun stations, turrets and at upper end of ammunition hoists.

95. A standard battle-lantern bracket shall be installed near each of these stations, so that the lantern may be permanently attached and ready for immediate service.

96. *Portable* hooks, for hanging the conductor and portables or battle lanterns, to be provided in convenient places for temporary stowage of the fixtures in turrets or about machinery.

97. *Cargo reflector*, for use at gangways in coaling ship and stowage, will be furnished with, and connected to, a length of 100 feet of double conductor plain and a receptacle plug.

98. *Navigator's lantern* to be furnished with, and connected to, 25 feet of double conductor plain and a receptacle plug.

99. *Diving lantern* to be furnished with, and connected to, 100 feet of double-conductor diving lamp, each wire of the conductor to be connected to a 25-ampere receptacle plug.

100. A 25-ampere switch and receptacle is to be provided on each bow and quarter, for use of the lantern. When required, by great length of the vessel, extra outlets shall be provided.

101. *Stay lights* shall be furnished with, and connected to, a length of double conductor; the length of conductor to be that best adapted for a hoist of at least 20 feet from the deck.

102. *Telegraph lights* to be furnished with, and connected to, a length of double conductor plain and a receptacle plug; the length of conductor to be that adapted for connection with the switch and receptacle.

103. The switch and receptacle to be located on the column of the mechanical engine-room telegraph.

104. The lamps of the *night-signalling sets* to be connected to the standard cable.

105. The lamp ladder will be suspended to an outrigger, to be fixed or pivoted as required, and fitted as best adapted for the use of the particular vessel. The lower end of the lamp ladder to be steadied by a galvanized-wire cable setting up with a turn buckle and plate inboard.

106. The keyboard to be secured on a bracket fastened to the bridge rail or on a suitable pedestal. A metal cover to be fitted to protect the keyboard from the weather.

107. The outriggers, keyboard, bracket and cover to be in conformity with the Bureau's designs.

108. The signalling set to be connected with a 25-ampere switch and receptacle, installed on the signal circuit.

Steam Pipes and Fittings.

109. Steam-pipe connections are to be so made that steam can be available from either the main or auxiliary boilers. All piping to be led with especial reference to head room and facility for removal and repair of pistons and valves. No joints to be placed over or in line with the dynamos or switchboard.

110. The main steam pipe is to be fitted with a stop valve, reducing valve and separator, to be located in the dynamo-room unless otherwise directed.

111. A trap is to be provided and connected to take the condensation of the separator, drip pipes of the engines, and drains from lower bends of piping.

112. A branch steam pipe, fitted with a stop valve near the main steam pipe, will be led for supply to each generating set.

113. All piping for steam and exhaust to be of copper.

114. The main exhaust pipe is to be fitted with a valve, placed where it will be accessible and in best position to ensure minimum condensation in the branch exhausts; and also with an oil eliminator, to collect the oil from the exhaust steam on its passage to the condenser, in all cases where cylinder lubricators are fitted on the steam pipes.

115. A sight feed cylinder lubricator is to be fitted in a suitable position on each branch steam pipe, if so directed.

116. The main steam pipe is to be tapped for the connection to the steam gauge; the main exhaust pipe to be tapped for connection to the combined vacuum and back-pressure gauge.

117. The steam gauge, clock and vacuum gauge are to be mounted together on a suitable backboard.

118. All piping is to be covered with an approved non-conducting material.

Dynamo-room Accessories.

119. The following are to be provided in the dynamo-room: An oil filter, well secured and of large capacity, that it may also serve the purpose of an oil receiver. If the construction of the filter includes heating coils, it will be connected with the steam and drip mains.

120. A *save-all*, for catching the waste oil from the drainpipe of the engine base.

121. An overhead *hoist* and *traveller*, with rails for each dynamo for handling the armatures.

122. *Lockers*, for stowage of instruments of frequent use, and a few pockets for cotton waste, etc.

123. A *wrench* and *tool board*, conveniently placed and arranged to secure the tools in place.

124. The following will be placed in the dynamo-room, if space permits, if not, in the electrical storeroom:

125. *Oil tanks*, for cylinder and lubricating oil, to be supplied with cocks, trays and facilities for filling and cleaning; the capacity to be as large as the available space will permit.

126. A *work-bench* and *vice*.

127. All accessories and appliances for dynamo-rooms and steam connections to be of approved design, operation and construction.

Foundations.

128. The deck under all generating sets is to be so supported and strengthened that it will easily sustain the weight and insure that the framing of the vessel will assist in securing rigidity and preventing vibration.

129. The bed plates should preferably rest in a metal pan, with edges turned up about two inches to catch waste oil and water; the pan to rest on and be secured to a wooden base, not less than two inches in thickness, to deaden vibration.

130. Cutting waterways in the wooden base and lining with lead is to be avoided, as the lead is readily injured and cut.

131. The wooden base should be protected from access of water in order to secure durability. All foundations to be leveled.

Switchboard and Connections.

132. Switchboards are to be installed with an especial reference to accessibility, and freedom from access of oil thrown by the moving parts of dynamos and engines.

133. It is desirable that sufficient room be allowed between the bulkhead and back of the switchboard to facilitate connections.

134. The slate panels constituting the switchboard shall be separated from the metal framework (or bulkhead) by a wooden framing; the wooden framing to embrace and lap over the edge of each panel, to hold it together in case of breakage. The panels to be secured to the framing by bolts, with countersunk heads, which will be in addition to those securing the framing to the metal framework; the holes for the bolts to

have ample clearance, so that the panels will be held by the pressure of the nuts only; the weight to be supported by a ledge on the wooden framing.

135. Dynamo and shunt rheostat leads will be installed in the standard molding prescribed for that use.

136. Dynamo and equalizer leads will have a cross section on the basis of 1,500 circular mils per ampere of the rated capacity of the dynamo.

137. When three or more dynamos are to be connected to the same switchboard, especial precaution is to be taken to insure a practical equality in resistance of the equalizer leads.

138. A double pole automatic circuit-breaking switch, of approved design, construction and operation will be connected in the positive and equalizer dynamo leads on the switchboard.

139. All rheostats are to be installed with reference to freedom from access of oil thrown by the moving parts of the engine.

140. Search-light rheostats to be located as conveniently near to the instrument board as space will admit, and to be marked with the names corresponding to their respective lights.

141. Switchboards and rheostats are to be raised as high above the deck as convenience of access to the appliances and available space will permit, and to be placed clear of the dripping from dead lights in the deck overhead.

ELECTRICAL INTERIOR COMMUNICATIONS.

Conduit and Molding.

142. *Conduit* will be used for all spaces in the water-tight system. It is to be preferred for use in all other locations; but in spaces where it may not be desirable to run it over woodwork, as in chart-house, emergency cabins and officers' quarters, standard wooden molding may be used.

143. It will be fastened to the metal of the ship by stout metal straps, at such intervals as will firmly secure it in place, prevent undue vibration and withstand any unusual strain to which it may be subject.

144. It shall be continuous and to be made water-tight at bulkheads by approved flanges and stuffing boxes.

145. Leads through armor will be made by tapping in on both sides, continuity to be secured by smooth-turning the end of one of the conduits, to a depth of the thread, for a length equal to the untapped thickness of the armor; the ends to butt together.

146. Connections to standard connection boxes to be made by tapping a short nipple, with right and left coupling, directly into the box. Standard bell-wire molding to be installed, as prescribed for that for lighting and motor circuits.

Wiring.

147. All wire, whether for use on dynamo current, battery or transformer, to be that prescribed by the specifications for bell wire and interior-communication cable; the specified bell wire and interior-communication cable to be used on all circuits, whether for call bells, telephones,

telegraphs or indicators, excepting where a standard special cable has been specified for a particular use.

148. Interior-communication cable to be used for all leads below the main deck, excepting for quarters and office calls in the nonwater-tight system; the governing principle to be to secure thorough water-tightness between the water-tight and nonwater-tight sections of the vessel, which will necessitate in some cases the extension of the cable into the nonwater-tight sections through the water-tight bulkhead. Interior-communication cable is also to be used for circuits to the conning tower, chart-house, military top, signal towers, emergency cabins and bridge.

149. Not more than 20 wires will be used in any one lead.

150. Type A 20 or Type 40 connection boxes will be used, as may be most suitable for the particular case, special reference being had to reducing the number of boxes to a convenient minimum.

151. All wire or cable to be run where directed and where accessible, that for circuits used in action to be kept below the water-line as much as possible.

152. Circuits used in action which are protected, and which are connected to exposed circuits, to be provided with action cut-out switches for cutting out the exposed portions of the circuits. Thorough water-tightness is to be observed for all leads into wiring appliances, through the bulkheads below the main deck, and through all decks.

153. The outer braid and tape on the ends of all bell wire and cable, where they are connected through gaskets in boxes, cut-outs or instruments, is to be removed, exposing the vulcanized rubber underneath to within one-eighth inch of the outside of the gland; special care to be observed not to cut into or injure the vulcanized rubber.

154. All wire and cable run through decks or bulkheads, when molding is used, must be led through standard stuffing tubes; when running through beams or bulkheads, and water-tightness is not required, the hole for the lead must be bushed with hard rubber, the hard rubber extending into the molding on each side.

155. No circuits to be led overhead in locations subject to heat, or through or into coal bunkers, unless specially authorized.

156. All conductors are to be run in conduit or molding. No cleating to be permitted in any appliances unless specially authorized and approved.

157. Tag boxes are to be provided with metal name-plates marked to correspond with the numbers shown on the drawings of the circuits.

158. The number of soldered joints in single-conductor circuits will be kept at a minimum, and entirely avoided, if practicable. When soldered joints are made, it is to be done by first cleaning the wires, then twisting closely together and heating sufficiently only to cause the solder to flow freely into the joint. The heating will preferably be done with a soldering iron. If a soldering lamp is used, special precaution will be taken to prevent overheating of the rubber.

159. The solder for making joints shall be of the rosin-core type; no flux of other than rosin to be used.

160. All joints shall be taped while warm with a layer of rubber tape,

and covered with an outside layer of cotton tape for protection against mechanical injury.

161. A dry location will be selected when joints are to be made in leads.

162. The interstices between wires or variation from full circle in outer surface, where large enought to admit of it, are to be filled with rubber tape. The tape for filling is to be cut to one foot in excess of the length of the tube, then soft rolled on itself, the axis of the spiral being in the direction of the length of the tape. These are to be laid in the interstices so that 6 inches will extend beyond each end of the tube when the conductors are in their normal position. The whole is then to be securely wrapped with rubber tape, lapping one-half of its width to same length as the fillers and to a sufficient thickness at the gasket to make it bind the taped conductors tightly. Where No. 16 B. & S. G. battery wires form sole components, they shall be closely grouped together. The inner interstices need not be filled, and the outer only when their number is other than seven and nineteen. The outer wrapping is to be done in every case where there is sufficient difference between diameters of the tube and laid-up conductors. The fillers should not be so made up as to increase to any degree the outer diameter of the cable.

163. It is intended that the tubes will be made practically water-tight by this method, and the work must be done to insure this result as far as possible.

164. All call bells and push-buttons to have name-plates; those for the bells to indicate the station from which the call is sent, and those for the buttons to indicate the station to which sent.

Circuits.

165. The circuits will be divided into the following classes:

1. Call-bell circuits.
2. Telephone circuits.
3. Telegraph circuits.
4. Indicator circuits.
5. Fire-alarm circuits.
6. General-alarm circuits.

166. *Call-bell circuits* will comprise—

Quarter's and office calls.
Voice-tube calls.

Wherever necessary to prevent confusion in calls to the same location, an annunciator will be installed, with a convenient number of drops.

167. *Quarter's call* will include the following:

168. *Commander-in-chief.*—Calls from staterooms, bathroom, saloon and office, to orderly and pantry; also a call from the signal tower to the orderly. Calls in each saloon, to be located at the table, to call the orderly and pantry.

169. *Captain.*—Calls from staterooms, bathroom, saloon and office, to orderly and pantry; a return call from the cabin to the chart-house, and calls from the emergency cabin to the chart-house, orderly and cabin pantry. Calls in each saloon, to be located at the table, to call the orderly and pantry.

170. *Wardroom.*—Calls from staterooms, bathroom and table, to the pantry; one table call to call the messenger. Additional calls in staterooms to be installed as follows:

Executive officer.—Call to office, master-at-arms and yeoman.

Chief engineer.—Call to each main engine-room and to the log-room.

Paymaster.—Call to pay office.

Surgeon.—Call to the dispensary.

Navigator.—Call to office and dynamo-room.

Marine officer.—Call to first sergeant.

171. *Junior officers.*—Calls from each stateroom and table to the pantry. In ships having no stateroom the call to be from the table only.

172. *Warrant officers.*—Calls from staterooms and mess-room to pantry. A call will be installed, at some convenient place, for the officer of the deck to call the cabin orderly when stationed on a lower deck; also a call, located on each deck used for quarters, to announce the departure of boats; the latter to have 6-inch single-stroke bell.

Office Calls.

173. *Executive officer.*—Calls to master-at-arms, yeoman and wardroom pantry.

Paymaster.—A call to the wardroom pantry.

Navigator.—Call to the dynamo-room and wardroom pantry.

Voice-tube Calls.

174. A return call will be installed at each end of continuous voice tubes. When voice tubes are connected through valves or hand connections, a return call will lead to the central station.

Telephone Circuits.

175. Telephonic connections between different locations are to be installed where directed. They are intended to take the place of, or to supplement, voice tubes between the locations. They will include the following: A direct circuit from the captain's cabin to the chart house. A circuit connecting the conning tower to the central station, turrets, torpedo tubes, steering engine-room and that main engine-room in which the voice tubes terminate. The locations mentioned to call the conning tower through an annunciator; the connections from the conning tower to be controlled by switches; the annunciator, transmitter, push-button, switches and bell to be combined in the same case. The switches to have name-plates indicating the connection. When installing telephones, positions will be selected for the instruments where least exposed to vibration; the mouthpieces to be 5 feet above the deck. Sections of telephone circuits which are run in molding, and with separate wires, are to be tagged at convenient intervals for facilitating tracing of wires; the ends of all wires, whether separate or in cable, to have metal tags marked to distinguish the particular wire. All circuits to be on separate batteries. A blue-print diagram of leads of the circuits, the location of batteries, instruments and tag boxes, with all connections, to be furnished. The

insulation resistance between circuits, and from each circuit to ground, to be not less than 1 megohm. The circuits to the conning tower shall be run inside of the armored tube; any sections of the conning-tower circuits, which are not protected by armor, shall be connected through an action cut-off switch.

Batteries for Quarters' and Office Calls.

176. The circuits will be divided into separate circuits, each to have its own battery. The batteries to be placed in battery lockers having a separate partition for each cell; the lockers to be located as near the respective annunciators as practicable; the partitions for the cells to be 4¼ by 4¼ inches inside measurement, and also to be on the front of the cells to prevent their falling out when the locker door is opened. The distance between shelves to be 9 inches. The door to be provided with a snap catch and a name-plate indicating the name of the circuit which the battery supplies.

Batteries for Voice-tube Calls, Telephones, Fire-alarm, and General-alarm Circuits.

177. A battery locker shall be provided in which all the batteries for voice-tube calls, telephone calls and those for operating general-alarm gongs shall be located. The cells to be grouped on trays containing not more than 12 cells each; each cell to be placed in a separate compartment 4¼ by 4¼ inches, separated by partitions 3 inches in height; each tray to be provided with handles for lifting, with push bolts for securing in place, and with a name-plate indicating the name of the circuit which the batteries of the tray supply. The voice-tube calls shall be on separate-battery circuits, and will include one of the larger annunciators with their push-buttons, and any separate bell or push-button call that perform similar service. The smaller annunciators, with their push-buttons and bells, may be collected in groups of two or three on the same battery circuit. It is intended in the foregoing arrangement of annunciators to avoid general interruption of service in case of fault in any circuit, and also to decrease the work on the batteries. The annunciators to be as near the voice tubes as practicable and in a safe and visible location. Rotary transformers, to be located in the dynamo-room, when practicable, will generally be used in lieu of the batteries on the foregoing circuits excepting for quarters, telephone and office calls; the transformers and batteries to be connected to the circuits through the standard transfer switch.

Push-buttons.

178. Push-buttons in quarters shall be of the nonwater-tight type; and, in staterooms, shall be mounted on the same blocks as the switch for the lights and located near the head of the berth. Push-buttons at tables shall be of the pear-push type, the cords to lead from ceiling buttons; cup hooks to be conveniently placed for hanging the bights of the cords. Push-buttons for voice tubes will be located, if practicable, directly over or under the mouthpiece.

Telegraph and Indicator Circuits.

179. When rheostats are used (for the purpose of using the dynamo current) the binding posts to which the connections are made will be equidistant from the ends, and protect the circuit from exposure to the full dynamo potential.

Engine Telegraph.

180. A transmitter for each engine-room will be installed on the bridge (in the chart-house and in the conning tower, if directed), with receivers in each engine-room and necessary return transmitters and receivers as may be necessary to the particular device. Standard action cut-out switches are to be placed on the circuits leading to the bridge and chart-house.

Helm Telegraph.

181. A transmitter to be located on the bridge, in the chart-house and in the conning tower. Receivers will be provided in the tiller-room, steering engine-room and at the wheels aft. Standard action cut-out switches are to be placed on the circuits leading to the bridge, chart-house and wheels aft.

Engine-revolution and Direction Indicators.

182. The transmitters to be in the shaft passages; in vessels not provided with shaft passages (or alley) to be located as far aft as possible. Receivers to be located in the engine-rooms, conning tower, chart-house and on bridge. Standard action cut-out switches are to be placed on the circuits leading to the chart-house and bridge.

Helm Indicators.

183. The transmitter to be located in the tiller-room. Receivers to be located in the steering engine-room, conning tower, chart-house, on the bridge and at the wheels aft. Standard action cut-out switches are to be placed on the circuits leading to the chart-house, bridge and wheels aft.

Fire-alarm Circuit.

184. The annunciators to be located in the dynamo-room unless otherwise directed. The thermostats to be placed in metal cases overhead in such storerooms as shall be directed, and overhead and on bulkheads in all bunkers. All thermostats in any one compartment to be connected in parallel.

General-alarm Circuits.

185. The gongs are to be so located in the living and working spaces as to be heard by all the ship's force. The gongs are to be operated by contact makers located in the chart-house, conning tower and the state-rooms for the captain and executive officers. All contact makers are to be placed at a distance from the push-buttons, to prevent mistake.

Installation of Range-finders.

186. The wiring to be the standard cable. The leads to be run below the protective deck, or where protected by armor, and run in conduit or

molding corresponding to the use of conduit or molding for the lighting circuits in the location. Water-tightness to be insured, and effected as prescribed for those circuits. The range-finder circuit will receive its current for the *battle-service* circuit, the connection to be made with a standard No. 14 B. & S. G. conductor, the conductor to be connected to a rheostat; the range-finder circuit to be taken from interior binding posts on the rheostats, to protect the circuit from the full voltage of the *battle-service* circuit. The rheostats are to be designed to provide current for both range-finder and range-finder telephone circuits.

187. The installation of all electrical apparatus for interior communications not mentioned in these specifications shall be under the direction of the Bureau of Equipment and according to specifications prepared by the Bureau as to material, apparatus and method of installation. All to be subject to approval.

INSTALLATION OF ELECTRIC OPERATORS FOR STEAM WHISTLES AND SIRENS.

188. The clockwork mechanism will be placed in the chart-house on one of the bulkheads, as directed. The connection to the signal circuit will be made with No. 14 B. & S. lighting conductors in lighting wire conduit and molding through a double pole switch to a branch junction box three-way. The connection to the controlling switch on the bridge is to be made with the standard whistle cable, triple conductor. The connection to the cable coupling case at the magnet case is to be made with the standard whistle cable, double conductor. Inside of the chart house the cables will be run in interior-communication molding. From the bridge deck to the rail a special deck tube will be used. The run from the cable coupling case to the desk of bulkhead will be made in conduit, ending in a flange. In going through the hood around the stack an angle flange will be used. The conduit will be secured to the stack at about every four feet by pipe supports. A sleeve expansion joint is to be placed in the conduit, between the cable coupling case and the upper support, to provide the increased length of the conduit required to accommodate for the expansion of the heated steam pipe leading to the whistle. The electric-whistle operator and signal system is to be fitted with accessories for proper installation as shown in the Bureau's drawing No. 809 H., and connected as per Bureau's drawing No. 811 A.

189. When the installation is complete, and before acceptance, the insulation resistance of all circuits must be tested out, and conform to the following specifications: *Circuits for continual service, battle service, general service, sea service* and *day service* must be connected up to all their outlets and show an insulation resistance of not less than 1 megohm between circuits, and from each circuit to ground. Search-light feeders and motor feeders must show an insulation resistance of not less than 5 megohms, the circuits not being connected up. The signal circuit will conform to the test for search-light feeders. The generating sets, wiring appliances, fixtures and accessories to pass the tests required by their respective specifications.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE SECONDARY BATTERY.

By LIEUT. F. K. HILL, U. S. Navy.

During the late war with Spain the writer was on the Iowa and had command of the secondary battery on the upper deck—sixteen 6-pounders and two 4-inch R. F.

So much has been written, in a popular way, of the merits of secondary battery, and there has also been so much talk on the subject, from which erroneous conclusions (in the writer's opinion) have been drawn, that the writer has thought to give his views from deductions made after seeing the battery under service conditions.

It was a general opinion in the Navy that since no good range-finder had been developed the secondary battery might be used for this purpose, and much has been written on the subject. It was found in actual service that against forts or in fleet action these guns could not be thus used, because, in the great number of shots delivered, those of a particular ship or of a particular gun could not be located, and therefore no range could be determined by an individual gun or group of guns. In action between two ships the secondary battery might, under some circumstances, be used as a range-finder, but it is the writer's belief that since the larger guns will begin an action they certainly will never stop firing to allow the smaller guns to get the range, and the range cannot be determined by a small gun unless the larger guns cease firing.

In the bombardment of forts at San Juan, Captain Evans soon saw that the secondary battery was making no impression, although the number of hits was great, so he ordered the small guns to cease firing, and from that time on the 6-pounder guns were not again used against forts.

July the 3d was the day on which the secondary battery in the popular mind came to the front, and yet if this action be carefully analyzed the secondary battery will not be so important as we are led to believe from common report. The secondary batteries of the large ships did what they were called on to do in the case of the torpedo destroyers, and that was legitimate and complete work in their line.

The secondary batteries of the large ships also did most of the damage to the four armored cruisers. Yet, does it follow from this that the main batteries should be reduced in number or size? The writer thinks not, for the following reasons:

1. The Spanish ships were whipped so quickly that there was no time to develop the ultimate fighting strength of our vessels.

2. The Spanish vessels were loaded with wood, and their destruction was due secondarily to this fact, as fire was an important feature in their destruction.

3. The Spanish gunners did no good shooting, so that our service of the secondary battery guns was never materially interfered with.

For these reasons the writer thinks that if the battle had been between two fleets of battleships, practically non-inflammable, with good gunners on both sides, the first part of the action would have seen the mutual destruction of the secondary batteries and crews, and the final test would have been between the heavy guns and the armor.

Therefore, let us not be led away by an accidental victory of small guns and say that we should have more rapid-firing guns and a reduction of the main battery, but rather let us keep on in our former paths with big ships and big guns, and let the little ones keep their place as *secondary*, for *secondary* they certainly are.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NAVAL RESERVES AND NAVAL VOLUNTEERS.

By LIEUTENANT R. C. SMITH, U. S. Navy.

To naval readers it is not necessary to expatiate on the experiences of Naval Reserves in the late war. The fleet was largely increased and it was necessary to man it. The one-year's men helped out materially, but they were not numerous enough to meet all requirements. As a result the Naval Reserves were utilized in the general service. It is known that they were not altogether satisfactory; it could not be expected that they should be; but on the whole they filled positions that would have been otherwise vacant, and some of them did very good work. The navy is indebted to them, and they should be made to feel it. The writer served a couple of months with a large contingent of them aboard an auxiliary cruiser. Actual hostilities had ceased at the time, and it was possible to observe these men after the excitement of war had subsided. They were intelligent and patriotic, and while all were not sailors, they did their work creditably. To have become the equal of man-of-war's men they would have had to continue permanently in the service. This of course was out of the question. But I often reflected that with their capacity and local organization and the time they could ordinarily command for drill and instruction, there were one or two specialized duties of real importance to the navy in the discharge of which they could be made actual experts.

The Government felt that much of the trouble of the Reserves was due to lack of uniformity in organization, drill and instruction. But as this will always be the case when there is no governmental supervision or control, the remedy seemed to lie in enrolling and training a reserve that could be called on with

confidence in emergencies like the one that lately confronted us; at least such is the impression I have gained from newspaper reports and the bill for enrolling a reserve now before Congress. This bill seems to follow the able report made by Lieutenant Southerland to the Assistant Secretary of the Navy. It is to be hoped it will pass, as it will accomplish a great deal of good in the right direction. It seems unfortunately to have aroused opposition in some quarters. I am not in a position to know if this will prove serious. I have had talks with a few reserve men, and the ground seems to be that the tendency will be to disrupt the local organizations. This of course would not be desirable, as the local training is of great importance in supplementing any drill and instruction that can be included in a government scheme.

The problem then is to encourage the local organizations as an important adjunct to the governmental enrollment. Any opposition that exists to the enrollment comes from that section of the present Naval Reserves, the individuals of which feel that they are not deep-sea sailors and do not desire to bind themselves to serve anywhere and at any duty to which the government may see fit to order them. When it is considered that the non-sailor element is largely in the majority in the Naval Reserves, it is seen that there are possibilities here of a serious complication.

There are, generally speaking, two classes of men available for re-enforcing the navy in time of war; men with previous nautical training and men without it, or with very little. If the former class was numerous enough to fill all the requirements the question would be simple enough; but it is well known that this is not the case. The numbers of available seamen are not nearly adequate to the navy's needs in time of war. Fortunately, of the other class there are many men of nautical inclination and some knowledge of the water who are ready at the call to war to render any service that lies in their power. Since it is impossible to obtain all the seamen that would be desirable, it will be decidedly to the interest of the navy to make use of these other men also. And to get the best results from their services, it will be necessary to determine in advance the character of their work, train them for it, and when war breaks out assign them to it. If to assure the success of the seaman reserve movement it is necessary to provide government supervision and control;

equally will it be necessary for the government to supervise and control the non-seaman organization and management.

To divide these classes again on slightly different lines, there are men who are ready in time of war to serve the country anywhere and on any duty, and there are men who are unable for various reasons to do this, but who would be glad to serve locally in such capacity as they could. As the national reserve will be composed of the former class alone, some other provision will be required to ensure the services of the latter class. Here seems a fitting place to draw a distinction between the two general classes referred to above. The term naval reserve has been used rather loosely since the incipiency of the movement. To make a distinction some State organizations have been called naval militia. The difference is this: The ordinary meaning of a reserve of anything, whether of force, or of men, or of money, is something held back, but available and ready for use in an emergency. Under this definition a true reserve would be composed of seamen alone, or of men with sufficient nautical and naval training to step aboard the man-of-war, settle down in their places, and thenceforth be to all intents and purposes a part of the regulars. This, I take it, is the scope of the present national reserve movement. As such it is a splendid thing and deserving of success.

The so-called State reserves were usually not reserves at all, that is, referring to perhaps nine-tenths of their membership; and this was the reason for the adoption of the term naval militia. It is an improvement on naval reserve in the meaning conveyed, though still open to objections. Militia in its derivation suggests soldiers; and though in the present day the naval service is said to be a military service, it seems good to stick to its own designation. To make a general distinction between the two classes why not limit the use of the term reserve to the seaman class alone, and characterize all the other available elements as naval volunteers? The term volunteer has sometimes been applied to the one-year's men, but without any real necessity, as these latter were regularly enlisted in the rates they were qualified to fill, the only distinction being in the term of service. Volunteer has in it something of the suggestion of amateur, which is very much the meaning to be conveyed. The men designated are mostly amateur sailors, and in war would be serving the

country for love and patriotism, or for the love of adventure; the result is the same.

The national reserve then takes cognizance of men who are sailors and have served aboard the man-of-war; or if they have not, can still be given sufficient training in peace time to make them useful and available in war for the regular duties of the blue-jacket afloat. Can not we also by additional legislation take cognizance of the men of nautical inclination and some local knowledge of the water who would be glad to serve their country in special directions and near their homes to the best of their abilities, the men whom it has been suggested above to call naval volunteers? Perhaps they also could be enrolled in a national organization after demonstrating their fitness in certain branches, which will be considered later. The national reserves and the national volunteers could then serve side by side in the same local organizations with mutual benefit. In time of war, the reserves would be called away, but the volunteers would continue under governmental control the same general work they had been drilled at in time of peace, and as far as possible under their own officers and organization. Rank, pay and privileges could be made equivalent in the two branches. It is perfectly possible that men qualified to serve in the reserves might for various reasons prefer the volunteers, or a volunteer might perfect himself and be able to pass an examination as a reserve. Men satisfactorily qualified could well be permitted to transfer from one branch to the other under suitable limitations.

While I do not propose in this paper to consider fully the employment of the naval volunteers, it is perhaps desirable to enumerate some of the duties to which they might appropriately be assigned. The reconnoissance of the coast and pilotage of the harbors and inland waterways, the preparation of war maps, the coast signal service, including the pigeon-messenger service, the mining and patrolling of the harbors, and the torpedo-boat service for local defense are all duties which it would be the part of policy to turn over to them at once.

For the reconnoissance of the coast there would be needed a few small craft of various kinds. A converted yacht in each district would be a good beginning. In addition, there should be one or two steam launches and several cutters. Records would be kept and the results of the work noted on the war maps and

charts. A knowledge of local pilotage would necessarily follow. The work would be directed entirely by the local organizations, but on a plan devised by the government and uniform for all districts. An annual report would be made of the results, and such portions published as were not confidential. A rivalry would thus result between the various districts to excel in the amount and quality of the work.

The present State organizations are already familiar with navy signaling. Under a central direction coast signal stations would be established at various points and manned entirely by the local volunteers. Practice would be undertaken with sufficient frequency to keep the men proficient. Telegraphy and the care of telegraph and telephone circuits would be a part of the requirements. Recruits for this branch could very readily be found. The pigeon-messenger service would fall naturally under the same central management. Distributed about the country are numerous clubs and private individuals interested in pigeon flying. They should be encouraged to join a national organization and perfect a plan in time of peace whereby pigeon cotes suitably located and an ample supply of trained birds could be at hand when wanted.

The mining of our harbors is now by law in the hands of the army engineers, though in most foreign countries these duties, with reason, devolve on the navy. The sailor's knowledge of boats and tides, and the fact that he must be trained in submarine mining in order to make use of it in operations on the enemy's coast, are sufficient reasons for giving him control of the system in our own waters. Added to this, that the mines are intended for use against hostile shipping, and that the sailor is familiar with the ways of ships and can often anticipate their movements and thus locate the mines in the most advantageous positions, and the case seems clear for the navy.

Here, indeed, is a field for our naval volunteers. With the large and growing knowledge of electricity, and of the handling and manipulation of electrical cables and telephone circuits, recruits for this branch of work could be had with ease. It is interesting to note that these were the men in demand by the army engineers for mining our harbors in the war just passed. It will be much better to train them in peace times for the requisite duties. With the knowledge of the water that every

resident of a seaport acquires in youth, and with instruction at stated intervals by officers of the regular service, these men would become actual mining experts, and their services would be of the greatest value to the government. The same men would compose the harbor patrol, the chief duty of which is regulating the traffic of the harbor and enforcing the rules relating to the channels through the mine fields. I believe there were disagreements on these points during the war, mainly by reason of the divided control.

But perhaps the most valuable, interesting and attractive work of any would be in connection with the local torpedo-boat defense system with which this country must surely very soon be provided. We know that, generally speaking, torpedo-boats are of two classes—destroyers, designed to accompany fleets, and the smaller coast defense boats operating from fixed bases. The destroyers would, as now, be officered and manned from the regular service, as would a certain number of the more seaworthy of the smaller boats, capable, as circumstances permitted, of keeping touch with the fleet in its operations near the coast. But of the remainder, there must be eventually a certain number stationed permanently at each prominent port on our coast. The regulars of the navy could not man all of these if they wished to. Who other than the local naval volunteers can possibly form the *personnel* of this service? The alternative will be in laying up the boats in large numbers, against which permanent practice I should like to register a most earnest protest. They must, of course, be laid up in the winter season at our northern seaports, and some will always be under repair; but with these exceptions they should be kept for the greater part continually in use. The training of a crew for effective work requires weeks of practice, and if some twenty odd officers and men are sent to launch a boat from the ways, get up steam and go out to look for the enemy, they are going to meet with ignominious failure should they come up with him in the first few days.

To organize a permanent local service we must look for these requirements. The officers and men must be watermen, if not deep-sea sailors. They must have a good knowledge of the pilotage of all harbors, bays, inlets, inland waterways and shoal channels in their own district. They must be of a mechanical turn of mind to appreciate the machinery of the boat and the

mechanism of the torpedo. These are the requirements, and it is easily seen that they can be met by material now in the present State organizations. The perfection of the material depends on practice; and as to that, if the boats should be made available, they would be in use by the different crews every long summer afternoon as a welcome respite from routine office or machine shop work.

The districts would be in command of regular officers, and there would have to be enough instructors and torpedo experts to keep the work moving. The boats themselves could be eventually officered and manned entirely from the naval volunteers, under whose care they would be hauled out and laid up in winter.

I have thus tried to show that there is work for a corps of naval volunteers as well as for the reserves. Of course, all of this work could be done by reserves if enough of them could be got together. But it does not seem likely that there will be more than enough for many years to fill up the war complement of the fleet. Therefore it becomes a necessity to utilize men who can acquire a working knowledge of various specialties but who are in no sense man-of-war's men, and therefore cannot form part of a true reserve.

The reserves and volunteers would have no trouble in coming together in the local organizations, and would, indeed, derive mutual benefit from the contact. If reserves alone are enrolled and the State organizations are still maintained, there must be inevitable bickerings between the members who do and those who do not belong to the national organization. By enrolling the volunteers also, it is probable that all cause for friction would disappear, and the local organizations would be stimulated and encouraged as never before. A man then with any nautical skill or liking, however slight, and with any mechanical or sailor-like knowledge up to that of the trained man-of-war's man, can find a place where he will fit in, and can count on being employed in time of war on a duty with which he is familiar, a consideration which it seems to me must be the beginning of any success in organizing the auxiliary navy.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

VIEWS OF ADMIRAL CERVERA REGARDING THE SPANISH NAVY IN THE LATE WAR.

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INTRODUCTORY.

Under the title "Vindication of the Navy," there appeared in the La Epoca, Madrid, November 5, 1898, this article, which is made up mainly of extracts from letters from Admiral Cervera, written previous to the declaration of war and continued to May 5. These letters were written by Admiral Cervera in protest against Spain rushing into war in face of certain defeat, due to the naval strength of the United States and the unpreparedness of the Spanish navy.

Cervera writes: "I ask myself if it is right for me to keep silent, and thereby make myself an accomplice in adventures which will surely cause the total ruin of Spain. And for what purpose? To defend an island which was ours but belongs to us no more, because even if we should not lose it by right in the war, we have lost it in fact, and with it all wealth and an enormous number of young men, victims of the climate and bullets, in the defense of what is now no more than a romantic ideal. Furthermore, I believe that this opinion of mine should be known to the Queen, and by the whole counsel of ministers.

". . . If our correspondence of the last two months is looked over it will be seen, not that I have been a prophet, but that I have fallen short of the true mark. Let us not have any illusions as to what we can do. . . .

"I have deemed it my duty to express my opinions to the proper authorities clearly and without beating around the bush. Now, let orders be given to me; I will carry them out with energy and decision. I am ready for the worst."

Spain had neglected her navy, and Cervera shows it was imprudent for her to attempt war against a superior naval power.

RICHARDSON CLOVER,
Chief Intelligence Officer.

NAVY DEPARTMENT,
OFFICE OF NAVAL INTELLIGENCE,
Nov. 29, 1898.

THE VINDICATION OF THE NAVY.

(From La Epoca, Madrid, November 5, 1898.)

The first judgment of a part of the public concerning the conduct of the navy in the combats of Cavite and Santiago has been already much modified. In the face of the evidence of official reports; of the praises and expressions of respect and admiration of the victors toward those who fought against them under disadvantageous circumstances; of the technical explanations given by foreign and Spanish scientific authorities, the unjust accusations of the first few days have faded away.

But still more complete must be the vindication of the navy, which has been treated with unjust severity and manifest partiality, when justice compels us to acknowledge that in all the events of the war the navy has done all that could be asked of it, considering its limited means; and that not only has it done its duty in naval actions, but it has also assisted the action of the land forces, as for instance in Santiago, now mounting and serving the batteries, which made it possible to prolong the resistance of the city; now landing its crews and fighting in the trenches so heroically that it was these naval forces that suffered the greatest losses.

As regards Admiral Cervera and his conduct from the time he took command of the fleet until the terrible battle of Santiago, we feel sure that not only will the supreme council of war and marine recognize that he carried the fulfillment of duty to the last possible extreme, but also that public opinion will have to atone to him for the injustice with which he has been treated, and will surround him with the respect deserved by those who, subordinating every consideration to the love of their country, pointed out to those who were blind the abyss toward which they were conducting the nation. His advice and representations were not heeded, and he heroically complied with the law of obedience, under which are all who wear the honorable military uniform.

We will not refer, for the present, to the battle of Santiago, which is now *sub judice*, but full light will be thrown upon this subject in due time. But previous events demonstrate the forethought of Rear-Admiral Cervera and the lamentable blindness of those who would not hear him, and are sufficient for the vindication of the sailors of Santiago.

From documents known by many chiefs and officers of the navy it appears that Admiral Cervera expressed himself always ready to give absolute obedience to the orders of the government; that he pointed out the dangers of a disastrous war with the United States while it was still possible to avoid it; that he repeatedly reported the deficiencies in the vessels under his command; that he persistently offered to come to Madrid to explain to the council of ministers the reasons why our fleet was going to certain destruction; that he was not allowed to explain these reasons to those about to take upon themselves the enormous responsibility of this war; that he was forced to sail without a war plan, against his opinion and that of all the commanders of the fleet, who signed a solemn protest declining the responsibility of the consequences; that finally many of the elements indispensable to put the ships in a fair condition were not supplied to him; that the Colón sailed without her turret artillery, and some of the Bilbao cruisers with some of the pieces and ammunition defective, and at least one of them with her speed very much reduced on account of the state of her bottom.

Though they possessed such conclusive and justifying documents, those officers had the self-denial, the patriotism, and the spirit of discipline not to reply to the attacks made against them, thus setting a fine example which is very rare in these times of personal and corps egotism, general insubordination, and wild passions. This noble conduct makes it still more necessary to give full satisfaction to the navy by making public, when the Cortes meet, all the official correspondence exchanged between Admiral Cervera and the minister of marine, as well as the supplementary private documents bearing on the subject.

We have had occasion to see some of these documents, and we wish to anticipate that justification, and to show that in reality it was not Cervera who lost the fleet, but those who, against the opinion of the Admiral and the commanders of the fleet, without even hearing Cervera's representations, sent the vessels to fight

under such conditions that they *had* to perish, thus sacrificing to the vain and noisy outcry of our jingoes the best vessels of Spain and the lives of hundreds of brave men.

Present circumstances prevent us, at this time, from making known much interesting data. However, the following is quite sufficient, we believe, to form a more just opinion of our navy.

In January, 1898, Admiral Cervera wrote to one of his relatives:

Deficiencies of the Naval Industry.

"About two years ago I wrote you a letter concerning our condition to go to war with the United States. I requested you to keep that letter in case some day it should be necessary to bring it to light in defense of my memory or myself when we had experienced the sad disappointment prepared for us by the stupidity of some, the cupidity of others, and the incapability of all, even of those with the best of intentions.

" To-day we find ourselves again in one of those critical periods which seem to be the beginning of the end, and I write you again to express my point of view and to explain my action in this matter, and I beg you to put this letter with the other one, so that the two may be my military testament.

" The relative military positions of Spain and the United States has grown worse for us, because we are extenuated, absolutely penniless, and they are very rich, and also because we have increased our naval power only with the Colón and the torpedo-destroyers, and they have increased theirs much more.

" What I have said of our industry is sadly confirmed in everything we look at. There is the Cataluña, begun more than eight years ago, and her hull is not yet completed. And this when we are spurred on by danger, which does not wake patriotism in anybody, while jingoism finds numerous victims, perhaps myself to-morrow. And the condition of our industry is the same in all the arsenals.

" Let us consider, now, our private industries. The Maquinista Terrestre y Maritima supplies the engines of the Alfonso XIII; Cadiz the Filipinas. If the Carlos V is not a dead failure, she is not what she should be; everything has been sacrificed to speed, and she lacks power. And remember, that the construction is purely Spanish. The Company of La Graña has not completed its ships, as I am told. Only the Vizcaya, Oquendo and Maria

Teresa are good ships of their class; but, though constructed at Bilbao, it was by Englishmen. Thus, manifestly, even victory would be a sad thing for us. As for the administration and its intricacies, let us not speak of that; its slow procedure is killing us. The Vizcaya carries a 14-cm. breech-plug which was declared useless two months ago, and I did not know it until last night. And that because an official inquiry was made. How many cases I might mention! But my purpose is not to accuse, but to explain why we may and must expect a disaster. But as it is necessary to go to the bitter end, and as it would be a crime to say that publicly today, I hold my tongue, and go forth resignedly to face the trials which God may be pleased to send me. I am sure that we will do our duty, for the spirit of the navy is excellent; but I pray God that the troubles may be arranged without coming to a conflict which, in any way, I believe would be disastrous for us."

State of the Fleet.

In the beginning of February Admiral Cervera wrote to a high official personage:

"Although I am sure that I am telling you nothing new, I think it is not idle, in these critical times, to make a study of the condition of the fleet. We must discount the Alfonso XIII, so many years under trials that it appears we shall not have the pleasure ever to count it among our vessels of war. The fleet is reduced to the three Bilbao cruisers, the Colón, the Destructor, and the torpedo-destroyers Furor and Terror. The three Bilbao battle-ships are practically complete, but the 14-cm. artillery, the main power of these vessels, is practically useless, on account of the bad system of its breech mechanism, and the bad quality of the cartridge cases, of which there are only those on board.

"The Colón, which is undoubtedly the best of all our ships from a military point of view, has not received her guns. The Destructor may serve as a scout, although its speed is not very high for this service in the fleet. The Furor and Terror are in a good condition, but I doubt if they can make effective use of their 75-mm. pieces. As for the supplies necessary for a fleet, we frequently lack even the most necessary. In this arsenal (Cadiz) we have not been able to coal, and both at Barcelona and Cadiz we could only obtain half of the biscuit we wanted, and that only because I had ordered 8,000 kilos to be made here. We

have no charts of the American seas, although I suppose that they have been ordered; but at the present time we could not move. Apart from this deficient state of the material, I have the pleasure to state that the spirit of the *personnel* is excellent, and that the country will find it all that it may choose to demand. It is a pity that a lack of better and more abundant material, greater supplies, and less hindrances are wanting to put this *personnel* in a condition to amply carry out its rôle!"

. . . . . .

"I note," said the Admiral in another letter, "what I am told concerning the heavy artillery of the Colón. It is to be very much regretted that there is always so much underhand work about everything, and that there should be so much of it now regarding the acceptance of the 254-mm. guns, because if we finally take them, it will seem that we are yielding to certain disagreeable impositions, and if things come to the worst, it seems to me we will have to accept, as the proverb says, 'hard bread rather than none'; and if we have no other guns, and these ones can fire at least 25 or 30 shots, we will have to take them anyhow, even though they are expensive and inefficient. And we must not lose time, so that the vessel may be armed and supplied with ammunition as soon as possible."

Some time afterwards, when matters were getting worse and worse, the Admiral was more explicit still. Shortly after the Dupuy de Lome incident he said:

"I do not know when the Pelayo and Carlos V will be able to join the fleet, but I suspect that they will not arrive in time. Of the first one I know nothing at all, but I have received some news concerning the second one, and certainly not very satisfactory as regards the time it will take for it to be ready. It seems to me that there is a mistake in the calculation of the forces we may count upon in the sad event of a war with the United States. In the Cadiz division I believe the Numancia will be lacking. I do not think we can count on the Lepanto. Of the Carlos V and the Pelayo I have already spoken. The Colón has not yet received her artillery, and if war comes, she will be caught without her heavy artillery. The eight principal vessels of the Havana station have no military value whatever, and, besides, are badly worn out, therefore they can be of very little use. In saying this I am not moved by a fault-finding spirit, but only by a desire to avoid illusions that may cost us very dear.

"Taking things as they are, however sad it may be, it is seen that our naval force when compared with that of the United States is approximately in the proportion of 1 to 3. It therefore seems to me a dream, almost a feverish fancy, to think that with this force, extenuated by our long wars, we can establish the blockade of any port of the United States. A campaign against them will have to be, at least for the present, a defensive or a disastrous one, unless we have some alliances, in which case the tables may be turned. As for the offensive, all we could do would be to make some raids with our fast vessels in order to do them as much harm as possible. It is frightful to think of the results of a naval battle, even if it should be a successful one for us, for how and where would we repair our damages? I, however, will not refuse to do what may be judged necessary, but I think it convenient to analyze the situation such as it is, without cherishing illusions which may bring about terrible disappointments."

Comparison of the Fleets.

The comparison of both navies, based upon the studies made in prevision of a war with the United States, suggested to the Admiral the following considerations on February 25, 1898:

"If we compare the navy of the United States with our own, counting only modern vessels capable of active service, we find that the United States have the battle-ships Iowa, Indiana, Massachusetts, Oregon and Texas; the armored cruisers Brooklyn and New York; the protected cruisers Atlanta, Minneapolis, Baltimore, Charleston, Chicago, Cincinnati, Columbia, Newark, San Francisco, Olympia, Philadelphia, and Raleigh, and the rapid unprotected cruisers Detroit, Marblehead, and Montgomery. Against this we have, following the same classification, the battle-ships Pelayo, Infanta Maria Teresa, Vizcaya, and Oquendo, armored cruiser Colón, and protected cruiser Carlos V, Alfonso XIII, and Lepanto; no fast unprotected cruisers; and all this supposing the Pelayo, Carlos V, and Lepanto to be ready in time, and giving the desired value to the Alfonso XIII. I do not mention the other vessels on account of their small military value, surely inferior to that of the nine gunboats, from 1,000 to 1,600 tons each, six monitors still in service, the ram Katahdin, the Vesuvius, and the torpedo-boats and destroyers,

which I do not count. I believe that in the present form the comparison is accurate enough.

"Comparing the displacements, we find that in battle-ships the United States have 41,589 tons against our 30,917 tons; in armored cruisers they have 17,471 tons against our 6,840; in protected cruisers 51,098 against 18,887, and in fast unprotected cruisers they have 6,287 and we none. The total of vessels good for all kinds of operations comprise 116,445 tons against 56,644 tons, or something less than one-half.

"In speed our battle-ships are superior to theirs, but not to their armored cruisers. In other vessels their speed is superior to ours.

"Comparing the artillery, and admitting that it is possible to fire every ten minutes the number of shots stated in the respective reports, and that only one-half of the pieces of less than 20 cm. are fired, and supposing that the efficiency of each shot of the calibers 32, 30, 28, 25, 20, 16, 15, 14, 12, 10, 17.5, 5.7, 4.7, and 3.7 be represented by the figures 328, 270, 220, 156, 80, 41, 33, 27, 17, 10, 4, 2, and 1, which are the hundredths of the cubes of the numbers representing their calibers expressed in centimeters $\left(\frac{(\text{caliber in cm.})^3}{100}\right)$, we find that the artillery power of the American battle-ships is represented by 43,822, and that of ours by 29,449; that of the American armored cruisers by 13,550, and that of ours (Colón) by 6,573; that of the American protected cruisers by 62,725, and that of ours by 14,600; that of the American unprotected cruisers by 12,300. Therefore, according to these figures, the offensive power of the artillery of the United States vessels will be represented by 132,397, and that of ours by 50,622, or a little less than two-fifths of the enemy's.

"To arrive at this appalling conclusion I have already said that it has been necessary to count the Pelayo and Carlos V, which probably will not be ready in time; the Lepanto, which surely will not be ready, and the Alfonso XIII, whose speed renders her of a very doubtful utility.

Impossibility of an Offensive Campaign.

"Now, to carry out any serious operations in a maritime war, the first thing necessary is to secure control of the sea, which can only be done by defeating the enemy's fleet, or rendering them

powerless by blockading them in their military ports. Can we do this with the United States? It is evident to me that we can not. And even if God should grant us a great victory, against what may be reasonably expected, where and how would we repair the damages sustained? Undoubtedly the port would be Havana, but with what resources? I am not aware of the resources existing there, but judging by this department, where everything is scarce, it is to be assumed that the same condition exists everywhere, and that the immediate consequences of the first great naval battle would be the enforced inaction of the greater part of our fleet for the rest of the campaign, whatever might be the result of that great combat. In the meantime the enemy would repair its damages inside of its fine rivers, and aided by its powerful industries and enormous resources. This lack of industries and stores on our part renders it impossible to carry on an offensive campaign.

. . . . . .

"If the control of the sea remains in the hands of our adversaries, they will immediately make themselves masters of any unfortified port which they may want in the island of Cuba, counting, as they do, on the insurgents, and will use them as a base for their operations against us. The transportation of troops to Cuba would be most difficult and the success very doubtful, and the insurrection, without the check of our army, which would gradually give way, and with the aid of the Americans, would rapidly increase and become more formidable.

"These reflections are very sad; but I believe it to be my unavoidable duty to set aside all personal considerations and loyally to represent to my country the resources which I believe to exist, so that, without illusions, it may weigh the considerations for and against, and then, through the government of His Majesty, which is the country's legitimate organ, it may pronounce its decision. I am sure that this decision will find in all of us energetic, loyal, and decided executors. Our motto is 'the fulfillment of duty.'"

MORE DEFICIENCIES—THE COUNTRY MUST BE TOLD THE TRUTH.

On February 26 the Admiral wrote the following:

"When I received yesterday the letter in which, among other things, you asked me if the Colón could go out for target practice, I answered that the vessel was ready, and at the same time I took measures so that the cartridge cases which might be used in that

practice should be recharged, but it appears that there is no furnace in which they can be reannealed, or a machine to reform the cartridge cases. The extra charges which the vessel brought (72 per gun) are therefore useless.

"I send to-day the official letter which I announced yesterday. Its conclusions are indeed afflicting, but can we afford to cherish illusions? Do we not owe to our country not only our life if necessary, but the exposition of our beliefs? I am very uneasy about this. I ask myself if it is right for me to keep silent, and thereby make myself an accomplice in adventures which will surely cause the total ruin of Spain. And for what purpose? To defend an island which was ours but belongs to us no more, because even if we should not lose it by right in the war, we have lost it in fact, and with it all our wealth and an enormous number of young men, victims of the climate and bullets, in the defense of what is now no more than a romantic ideal. Furthermore, I believe that this opinion of mine should be known by the Queen, and by the whole council of ministers."

That this thoughtful and patriotic advice was not favorably received by the government is shown by the following letter a few days afterwards:

"Yesterday I received your letter of the 28th, and I regret very much the painful impressions caused by my remarks; but I am not surprised, because they are truly sad, and still, perhaps, they fall beneath the mark, judging from anything one sees. Just now we have another proof of this in the fact that the difficulty of obtaining cartridge cases for the Colón arises from the want of means (money), and this on the eve, perhaps, of a war against the richest nation in the world. I do not wish to dwell too much on this point, for no practical result could be obtained. But every detail points out either our lack of means or our defective organization, and, above all, our utter lack of preparation.

"I have deemed it my duty to express my opinions to the proper authorities clearly and without beating around the bush. Now let orders be given to me; I will carry them out with energy and decision. I am ready for the worst."

More Data Regarding our Inferiority—Danger to the Philippines.

"An examination of our forces," said the Admiral on March 25, "based upon what I already know and upon recent informa-

tion and observation, not only confirms what I said, but shows it to be still worse. I have visited the Vitoria, on which I counted, and from my visit I have drawn the conviction that we can not count on her for the present conflict. Neither does my information permit me to count on the Pelayo, Carlos V, or Numancia. And yet, as this opinion is not based upon personal observation, I include them in the enclosed statement. Whatever may be the direction given to the conflict, either war, negotiations direct, or through a third party, an arbitrator or otherwise, the longer the decision is delayed the worse it will be for us. If it is war, the longer it takes to come the more exhausted we will be. If it is negotiation of any kind, the longer it is postponed the greater will be the demands, each time more irritating, which will be presented by the United States, and to which we will have to yield in order to gain time in the vain hope of improving our military position. And as our position can not be improved, let us see what we can expect from a war under such conditions.

"It would be foolish to deny that what we may reasonably expect is defeat, which may be glorious, but all the same, defeat, which would cause us to lose the island in the worst possible manner. But even supposing an improbability, that is, that we should obtain a victory, that would not change the final result of the campaign. The enemy would not declare itself defeated, and it would be foolish for us to pretend to overcome the United States in wealth and production. They would recover easily, while we would die of exhaustion, although victorious, and the ultimate result would be always a disaster. Only in case we could count on some powerful ally could we aspire to obtain a satisfactory result.

"But, besides having to discount the high price to be paid for such an alliance, even then we would only be postponing the present conflict for a few years, when it would become graver than it is to-day, as is the present insurrection in comparison with the last.

"Even admitting the possibility of retaining Cuba, this island would cost us enormous sacrifices by the necessity of being constantly armed to the teeth. And here the problem already pointed out by somebody arises: Is the island worth the ruin of Spain? (Silvela in Burgos.) I do not speak on the subject of privateering, because it seems to me that no man acquainted with history

can attach any value to privateering enterprises, which nowadays are almost impossible on account of the character of modern vessels.

"The accompanying statement shows that our forces in the Atlantic are approximately one-half of those of the United States, both as regards tonnage and artillery power. I have never thought of the forces which the United States have in the Pacific and Asia in connection with the development of events in the West Indies; but I have always considered these forces a great danger for the Philippines, which have not even a shadow of a resistance to oppose to them. And as regards the American coasts of the Pacific, the United States have no anxiety about them. I think you are mistaken in believing that during the month of April our situation will change. As I have said above, I am sure that neither the Carlos V, the Pelayo, the Vitoria, or the Numancia will be ready, and nobody knows how we will be as regards 14-cm. ammunition. It seems sure that by the end of April the 254-mm. guns of the Colón will not be mounted. Even if I were mistaken, then our available forces in the West Indies would be 49 per cent of that of the Americans in tonnage, and 47 per cent in artillery.

"Our only superiority would be in torpedo-boats and destroyers, provided all of them arrive there in good order.

"I do not know exactly what are the sentiments of the people concerning Cuba, but I am inclined to believe that the immense majority of Spaniards wish for peace above all things. But those who so think are the ones who suffer and weep inside of their own houses, and do not talk so loud as the minority who profit by the continuation of this state of affairs. However, this is a subject which it is not for me to analyze.

"Our want of means is such that some days ago three men went overboard while manning the rail for saluting, through the breaking of an old awning line. A new line had been asked for fifty days ago, but it has not yet been replaced. In old times, forty-three days after the Hernan Cortes was laid down the vessel was at sea. It is now fifty-one days since I requested the changing of certain tubes in the boilers of a steam launch of the Teresa, and I do not yet know when it will be done. This will probably be the proportion between us and the United States in the repair of damages, in spite of our having the Havana dock, which is the

principal thing, but not all. As for the crews, I do not know them, but I may say that the crews that defeated our predecessors at Trafalgar had been recruited in the same way.

"This is my loyal opinion, and for the sake of the nation, I express it to the Government. If it is thought advisable for me to express it personally, I am ready to start at the first intimation. After I have done this, thus relieving my conscience of a heavy weight, I am quite ready to fulfill the comparatively easy duty of conducting our forces wherever I may be ordered, being sure that all of them will do their duty.

North Atlantic Squadron.

SPAIN.

Protected vessel actually there, or unprotected but with a speed of over 15 miles:

	Displacement.	Artillery.
Vizcaya	7,000	6,130
Oquendo	7,000	6,130
Marques de la Ensenada	1,064	1,000
UNITED STATES.		
Same kind of vessels:		
New York	8,200	6,400
Indiana	10,288	9,304
Massachusetts	10,288	9,304
Texas	6,315	550
Brooklyn	9,271	7,880
Iowa	11,410	8,360
Montgomery	2,089	4,100
Marblehead	2,089	4,100
Detroit	2,089	4,100
Terror	3,600	2,896
To these may be postively added:	65,639	60,994
SPAIN.		
Infanta Maria Teresa	7,000	6,130
Cristóbal Colón	6,840	8,490*
Alfonso XIII.	4,826	4,340
	18,666	18,960
UNITED STATES.		
Minneapolis	7,375	4,790
Columbia	7,375	4,790
	14,750	9,580

* Without the 25-cm. guns, the value of which is represented by 1,248.

Doubtful additions:

SPAIN.	Displacement.	Artillery.
Pelayo	9,917	6,987
Carlos V.	9,260	5,620
	19,167	12,607
UNITED STATES.		
Atlanta	3,000	4,270
Charleston	3,730	4,570
Chicago	4,500	4,470
Newark	4,098	6,740
Philadelphia	4,324	7,640
Dolphin	1,485	700
Yorktown	1,703	3,320
	22,840	31,710
In the South Atlantic they have:		
Cincinnati	3,200	4,795

All the other vessels have very little military value, with the exception of the torpedo-boats and destroyers, not mentioned in this statement, including the Katahdin and Vesuvius.

Cervera wished to Explain his Opinion to the Council of Ministers.

Admiral Cervera's already expressed desire to personally inform the council of ministers was still more clearly expressed under date of March 16.

"Yesterday I received your favor of the day before, by which I see that our opinions agree concerning the conflict which threatens our unfortunate country. As both of us are animated by the best desires, such agreement was sure to come. It also appears that the whole government participates in this opinion, but I am afraid that there may be some minister who, while believing that we are not in favorable conditions, may have been dazzled by the names of the vessels appearing in the general statement, and may not realize how crushing a disproportion really exists, especially if he is not thoroughly aware of our lack of everything that is necessary for a naval war, such as supplies, ammunition, coal, etc. We have nothing at all. If this fear of mine is well founded, I think it is of the greatest importance that the whole council of ministers without exception be fully and clearly informed of our terrible position, so that there may not remain the least doubt that the war will simply lead us to a terrible disaster, followed by a

humiliating peace and the most frightful ruin; for which reason it is necessary not only to avoid the war but to find some solution which will render it impossible in the future. If this is not done, the more time is spent, the worse will be the final result, whether it is peace or war.

"From this reasoning, as clear as daylight to me, it appears that since we can not go to war without meeting with a certain and frightful disaster, and since we can not treat directly with the United States, whose bad faith is notorious, perhaps there is nothing left for us to do but to settle the dispute through arbitration or mediation, provided the enemy accepts. However, this order of consideration does not come within my sphere of duty, which, as the chief of the squadron, is limited to reporting the state of military affairs and then carrying out the orders of the Government. The latter, however, must be fully informed of the situation. Before dropping this subject, I must insist that perhaps it would be well for me to verbally inform the members of the Cabinet, and to say that I am ready to start at the first intimation.

"Concerning the available forces and what may be expected of them: I will be very glad if Ansaldo carries out his promise about the 254-mm. guns of the Colón. The 14-cm. cartridge cases are absolutely necessary. This vessel has only thirty, and it is to be supposed that the stores of the Oquendo and Vizcaya are not better supplied. For the present the firm is supplying only one hundred per week; and supposing that the first ones have already arrived or will arrive in Cadiz one of these days, at this rate we won't have finished until October. Then they have to be charged, therefore they can never be ready in time for the present conflict. I thought I would have the first ones by January, and I will not have them until April. The engines of the Pelayo are ready, and the vessel can sail, but how about the secondary battery and the armored redoubt? These will not be ready. If the old battery could be mounted! But I doubt it; the ports will not permit it. I have heard it said that the crew which brought the Pelayo was taken from the Vitoria, which is another proof of our excessive poverty. It will be very well if the Carlos V is soon ready, but I understand that the 10-cm. battery has not yet been mounted, and then the trials are to be made.

"I never had great confidence in the purchasing of vessels.

Too much fuss is made over every detail by ignorant people. It was through this that we lost the Garibaldi, and now we have lost the Brazilian cruisers. In fact, we have only secured the Colón, an excellent ship, but which has not yet arrived, and the Valdes. And supposing that we had everything our own way, and that Providence should grant us a victory, which is highly improbable, we would then find ourselves in the condition explained in my last, and which it is not necessary to repeat. It only rests for me now to be informed of the destination of the fleet. I believe the Teresa ought to be in Cadiz, where the cartridge cases are to be recharged, and she could sail as all her guns were mounted.

"I will insist no more, but the voice of my conscience, animated by my love for my country, tells me that in saying this I am fulfilling my unavoidable duty."

Condition of the Fleet Immediately before the War.

In the month of April, shortly before the war, Cervera wrote:

"My fears are realized. The conflict is coming fast upon us; and the Colón has not received her big guns; the Carlos V has not been delivered, and her 10-cm. artillery is not yet mounted; the Pelayo is not ready for want of finishing her redoubt, and, I believe, her secondary battery; the Vitoria has no artillery, and of the Numancia we had better not speak.

"But after all I am glad the end is coming. The country can stand this state of affairs no longer, and any arrangement will be a good one, however bad it looks, if it comes without our having to lament a great disaster, as may happen if we go to war with a few half-armed vessels, and without want of means and excess of incumbrances."

A few days afterwards he wrote:

"On account of the general anxiety it is very important to think of what is to be done, so that, if the case arises, we may act rapidly and with some chance of efficiency, and not be groping about in the dark, or like Don Quixote, go out to fight windmills and come back with broken heads.

"If our naval forces were superior to those of the United States, the question would be an easy one. All we would have to do would be to bar their way. But on the contrary our forces are very inferior to theirs. To endeavor to bar their way, which

could only be done by giving them a decisive naval battle, would be the greatest of follies. That would simply mean a sure defeat, which would leave us at the mercy of the enemy, who would easily take a good position in the Canaries, establish there a base of operations, crush our commerce, and safely bombard our maritime cities. It is therefore absolutely necessary to decide what we are going to do, and without disclosing our proposed movements, be in a position to act when the time comes.

"This was the substance of my telegram, and my ideas have not changed since then. If we are caught without a war plan, there will be vacillations and doubts; and, after defeat, there may come humiliation and shame."

On the eve of the war Cervera justly lamented the lack of a plan as follows:

"I regret very much to have to sail without having agreed upon some plan, even in general lines, for which purpose I repeatedly requested permission to go to Madrid. From the bulk of the telegrams received I think I see that the government persists in the idea of sending the little squadron (torpedo-boat flotilla) to Cuba. That seems to me a very risky adventure, which may cost us very dear, for the loss of our flotilla and the defeat of our squadron in the Caribbean Sea entails a great danger for the Canaries, and perhaps the bombardment of our coast cities. I do not mention the fate of the island of Cuba because I have anticipated it long ago. A naval defeat would only precipitate its ultimate loss, while if left to defend itself with its present means, perhaps it would give the Americans some annoyance. We must not deceive ourselves concerning the strength of our fleet. If our correspondence of the last two months is looked over it will be seen not that I have been a prophet, but that I have fallen short of the true mark. Let us not have any illusions as to what we can do."

The last documents relating to the sailing of the fleet from Cape Verde are the most interesting. They show what was the condition of the vessels on the 19th of April, the day before the rupture of relations. Admiral Cervera wrote from Saint Vincent, Cape Verde:

"The boilers of the Ariete are practically out of service, so that this vessel, instead of being an element of power, is the nightmare of the fleet. She could only be used for port defense.

The boilers of the Azor are eleven years old, and are of the locomotive type. As for the Furor and Terror, their bow plates give as soon as they are in a sea way, and some of their frames have been broken. The Pluton had an accident of this kind when coming from England, and had her bows strengthened at Ferrol.

"I do not know whether the port of San Juan de Puerto Rico affords good protection for the fleet. If it does not, and if the port of Mayaguez can not be effectively closed, the fleet would be in a most unfavorable position. However, before forming a judgment, I shall await the arrival of the Vizcaya, whose captain, Eulate, is thoroughly acquainted with Puerto Rico. I am constantly preoccupied about the Canaries. It will be necessary to close and fortify the port of Graciosa Island, as well as the island commanding the port of La Luz in Grand Canary.

"The idea of sending the fleet to Cuba seems to have been abandoned, I believe very wisely.

"Concerning Puerto Rico, I have often wondered whether it would be wise to accumulate there all our forces, and I do not think so. If Puerto Rico is faithful, it will not be such an easy job for the Yankees; if it is not faithful, it will inevitably follow the same fate as Cuba, at least as regards us.

"On the other hand, I am very much afraid for the Philippines and the Canaries, as I have said before; and above all, the possibility of a bombardment of our coast, which is not impossible, considering the audacity of the Yankees, and counting, as they do, with four or five vessels of higher speed than our own. For all these reasons, I am doubtful as to what it would be best for me to do; and I will not take any decision without the opinion of the council of captains, as prescribed by the ordinances.

"I leave this letter open until to-morrow, in case something should happen.

"I have just now been informed that the Vizcaya and Oquendo are in sight. I have had the pleasure of seeing them come in and of greeting their captains. The crews are in the best of health and spirits, but the Vizcaya needs docking badly. During the trip from Puerto Rico she burned 200 tons more than the Oquendo, which means a diminution of her speed of from 3 to 5 knots according to my reckoning, and a diminution of her sphere of action of from 25 to 35 per cent, thus losing the advantage of

speed. Both are now coaling, but it is a long job, for, unfortunately, we do not feel at home here. We are indeed unlucky!"

Council of War of the Commanders of the Fleet.

It is well known that before the sailing of the squadron the commanders of the vessels held a council of war on board the Colón, on April 21.

This is what Cervera wrote:

"The council lasted nearly four hours. The prevailing spirit was of the purest discipline, characterized by the high spirit which animates the whole fleet, and especially the distinguished commanders, who are an honor to Spain and the navy, and whom it is my fortune to have as companions in these critical circumstances. The first and natural desire expressed by all was to go resolutely in quest of the enemy, and to surrender their lives on the altar of the mother country; but the vision of this same mother country abandoned, insulted, and trod upon by the enemy, proud of our defeat—for nothing else can be expected by going to meet them on their own ground with our inferior forces—forced them to see that such sacrifice would not only be useless but harmful, since it would place the mother country in the hands of an insolent and proud enemy, and God only knows what the consequences might be. I could see the struggle in their minds between these conflicting considerations. All of them loathe the idea of not going immediately in search of the enemy, and finishing once and for all. But, as I said before, the specter of the country violated by the enemy rose above all other considerations, and, inspiring themselves with that courage which consists in braving criticism and perhaps the sarcasm and accusations of the ignorant masses, which know nothing about war in general and naval warfare in particular, and which believe that the Alfonso XIII or the Christina can be pitted against the Iowa or Massachusetts, they expressly and energetically declared that the interests of the mother country demanded this sacrifice from us.

"One of the captains had certain scruples about expressing his opinion, saying that he would do what the Government of His Majesty should be pleased to order; but as all of us, absolutely all, shared these sentiments—it is hardly necessary to say—his scruples were soon overcome. Another of the captains, certainly not the most enthusiastic, but who may be said to have repre-

sented the average opinion prevailing in the council, has written, by my order, his ideas, which reflect, better than I could express them, the opinions of all. This document exactly expresses the opinion which prevailed in the meeting.

"An act was signed in which it was stated that, having met by order of the commander-in-chief and under his presidency, the second in command and the captains of the vessels, the president submitted to discussion the following point:

"'Under the present circumstances of the mother country, it is expedient that this fleet should go at once to America, or should it stay to protect our coasts and the Canaries, and to provide for any contingency?'

"Several opinions were exchanged concerning the probable consequences of our campaign in the West Indies; the great deficiencies of our fleet compared with that of the enemy were made manifest, as well as the very scanty resources which the islands of Cuba and Puerto Rico are able to offer for the purpose of establishing a base of operations. In consideration of this, and the grave consequences for the nation of a defeat of our fleet in Cuba, thus leaving unobstructed the coming of the enemy against the Peninsula and adjacent islands, it was unanimously agreed to call the attention of the government, by means of a telegram, in which the commander-in-chief of the squadron, in agreement with the second in command and the commanders of the vessels, suggested to go to the Canaries. The Ariete—it said—boilers in bad condition, those of the Azor very old, Vizcaya needs docking to paint bottom if speed is to be maintained. Canaries would be protected against a rapid descent of the enemy, and all the forces would be in a position, if necessary, promptly to come to the defense of the mother country."

Opinion of Señor Concas.

The opinion of Captain Victor M. Concas, commander of the battle-ship Infanta Maria Teresa, concerning the subjects presented for discussion by the admiral of the fleet at the council of war held on board the Christóbal Colón, was as follows:

"(1) That the naval forces of the United States are so immensely superior to our own in number and class of vessels, armor and artillery, and in preparations made—besides the advantage given them by the insurrection in Cuba, the possible one in

Puerto Rico, and the one still existing in the East—that they have sufficient forces to attack us in the West Indies, in the Peninsula and adjacent islands, and in the Philippines. That since no attention has been paid to that archipelago, which was perhaps the most urgent, in order to reduce our vulnerable points, and which could have been done with a single battle-ship, to-day any division of our limited forces and any separation from the European seas involves a strategic mistake which would bring war to the Peninsula, a frightful disaster to our coasts, the payment of large ransoms, and perhaps the loss of some island. As soon as this fleet leaves for the West Indies it is evident—as has happened already more than once (sic)—that the American flying squadron will sail for Europe; and even if its purpose was only to make a raid or a demonstration against our coasts, the just alarm of all Spain would cause the enforced return of this fleet, although too late to prevent the enemy from reaping the fruits of its easy victory.

"The only three vessels of war remaining for the defense of the Peninsula, the Carlos V, the Pelayo, whose repairs are not yet finished, and the Alfonso XIII, of very little speed, are not enough for the defense of Spain, and in no way for that of the Canaries. The yacht Giralda and the steamers Germania and Normania are vessels of no fighting qualities and add no strength to our navy.

"(2) The plan of defending the island of Puerto Rico, abandoning Cuba to its fate, is absolutely impossible, because, if the American fleet purposely destroys a city of the last-named island, in spite of all the plans of the government upon the subject, and even if it should be the maddest thing in the world, the government itself would be forced by public opinion to send this fleet against the Americans, under the conditions and at the point the latter might choose.

"(3) Even deciding upon the defense of Puerto Rico alone, the trip across to-day, after the practical declaration of war, without a military port where the fleet might reorganize itself on its arrival, and without an auxiliary fleet to keep the enemy busy—who, I suppose, will make St. Thomas its base of operations—is a strategic error the more deplorable because there have been months and even years of time to accumulate the necessary forces in the West Indies. It seems probable, judging from the infor-

mation acquired, that the supplies accumulated at St. Thomas are intended by the enemy to establish a base of operations in the vicinity of our unprotected Vieques (Vierges). For all these reasons the responsibility of the trip must remain entirely with the government.

"(4) Adding these three battle-ships and the Cristóbal Colón, without its big guns, to the two remaining in the Peninsula and to the few and old torpedo-boats which we have left, it is possible to defend our coast from the Guadiana to Cape Creus, including the Balearic and the Canaries, thanks to the distance of the enemy from its base of operations. This defense, however, will have to be a very energetic one if the enemy brings its best ships to bear on us.

"(5) It is very regrettable that there are not enough vessels to cover all points at one time; but duty and true patriotism compel us to clearly express the resources which the country gave us, and the necessities which present circumstances bring on the country in danger.

"(6) Lastly, I believe that the military situation should be made known to the minister of marine, reiterating our profoundest subordination to his orders, and our firm purpose most energetically to carry out the plans of operations he may communicate to these forces. But after pointing out the probable consequences, the responsibility must remain with the government."

From Cape Verde.

Finally, on April 22, the Admiral said:

"It is impossible for me to give an idea of the surprise and astonishment experienced by all on the receipt of the order to sail. Indeed that surprise is well justified, for nothing can be expected of this expedition except the total destruction of the fleet or its hasty and demoralizing return; when here in Spain it might be the safeguard of the nation.

"You talk about plans, and in spite of all my efforts to have some laid out, as it was wise and prudent, my desires have been disappointed. How can it be said that I have been supplied with everything I asked for? The Colón has not yet her big guns, and I asked for the bad ones if there were no others. The 14-cm. ammunition, with the exception of about 300 shots, is bad. The defective guns of the Vizcaya and Oquendo have not

been changed. The cartridge cases of the Colón can not be recharged. We have not a single Bustamante torpedo. There is no plan or concert, which I so much desired and called for so often. The repairs of the servomotors of the Infanta Maria Teresa and the Vizcaya were only made after they had left Spain. In short, this is already a disaster, and it is to be feared that it will be a more frightful one before long. And perhaps everything could be changed yet! But I suppose it is too late now for anything that is not the ruin and the desolation of our country.

"The Vizcaya can no longer steam, and she is only a boil in the body of the fleet.

"But I insist no more. The act has been done, and I will try to find the best way out of this direful enterprise."

The following are the last letters we know of:

"SAINT VINCENT (CAPE VERDE), *April* 24, 1898.

"I have just received the telegram ordering us to start, and I have given orders to tranship from the Cadiz to these vessels coal, supplies, crews, and the artillery of the destroyers, which was on board the Cadiz.

"I intended to sail without finishing the provisioning of the vessels, but since the Cadiz is to stay, I have decided to ship as much coal as possible. I will try to sail to-morrow.

"As the act has been consummated, I will not insist upon my opinion of it. May God grant that I be mistaken! You see I was right when I said that by the end of April the Pelayo, Carlos V, Vitoria, and Numancia would not be finished; the Colón would not have its big guns, unless we took the bad ones, and we would not have the new 14-cm. ammunition with which to fight, etc.

"With an easy conscience I go to the sacrifice, but I can not understand that decision of the navy* general officers against my opinions.

"I have been informed of the sailing of a cargo of coal for Puerto Rico, where it is supposed to arrive on the 11th or 12th

* In a council of eighteen general officers, fourteen voted for the immediate sailing of Cervera's fleet from Cape Verde. Generals Gomez, Imaz and Lazaga voted against it until the re-enforcement of the fleet by the Pelayo, Carlos V, Alfonso XIII and Lepanto and the three destroyers remaining in the Peninsula. Generals Butler and Mozo shared this opinion conditionally, subordinating it to the decision of the government.

of May, but I am afraid lest it should fall into the hands of the enemy.

"It is a mistake to suppose that I can accept or avoid a naval battle at will. The Vizcaya, on account of her stay in Havana and the nine months without cleaning her bottom, is nothing but a buoy, and I can not abandon her."

ONE TELEGRAM FROM VILLAAMIL.

"AT SEA, *May* 5, 1898.

"DEAR JUAN: To complete our collection of documents, I think you should have the inclosed copy of a private telegram from Villaamil to Sagasta. I send you this letter by means of two destroyers which I am sending to Martinique in search of news. All is well on board, and the spirit is excellent. We shall see what God has in store for us. The final result is not doubtful, but if only we could start with a good lucky stroke! God be with us! Good-by. Regards to your folk, etc.

"PASCUAL" (Cervera's first name).

[Copy of Telegram.]

PRAXEDES SAGASTA, *Madrid:* *April* 22, 1898.

In view of importance to the country of destination of this fleet, I deem it expedient you should know, through a friend who does not fear censure, that, while as seamen we are all ready to die with honor in the fulfillment of duty, I think it undoubted that the sacrifice of these naval forces will be as certain as it will be fruitless and useless for the termination of the war, if the representations repeatedly made by admiral to minister of marine are not taken into consideration.

F. VILLAAMIL.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

COMMENTS OF REAR-ADMIRAL PLÜDDEMANN, GERMAN NAVY, ON THE MAIN FEATURES OF THE WAR WITH SPAIN.

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INTRODUCTORY.

This able analysis of the main features of the Spanish-American war by M. Plüddemann, Rear-Admiral, German navy, presents in a comprehensive form many of the technical deductions of the late war. He comments on the high quality and endurance of our navy ordnance and on the defective results from the navy fuse now in use.

As regards the question of the importance of the Navy controlling the transport service, his reference to the landing of the army at Daiquiri is instructive. Referring to the want of control and discipline on board the merchant steamers chartered as transports for service under the Quartermaster's Department of the Army—that control and discipline at sea which foreign military authorities have long since by experience recognized can only be obtained through the navy—he states:

> Under these circumstances it is not strange that the landing of the provisions, guns and ammunition, and the entire equipment, all of which were so much needed in this locality, which offered no resources, was effected with such slowness that the troops were reduced from the outset to the meager rations which each man carried with him.

RICHARDSON CLOVER,
Chief Intelligence Officer.

DECEMBER 21, 1898.

MAIN FEATURES OF THE SPANISH-AMERICAN WAR.

By M. PLÜDDEMANN, Rear-Admiral, German Navy.

(Translated from the Marine-Rundschau, November, 1898.)

While the events of the war just ended show nothing which might lead to a radical revolution of present ideas as to rational warfare and the use of modern war material, and while no essentially new appliances have been made use of which might cause us to anticipate a change in the floating material or the weapons of the sea powers, still the war has enriched former experiences. But, on the other hand, it might lead to erroneous conclusions, as many good devices did not have a chance to be tested, the weakness of the adversary making them superfluous, and others not good did not have bad results, because they were counterbalanced by the defects and mistakes on the part of the enemy or by other favorable circumstances.

The following is a discussion of the points which are of special interest to the naval officer:

I. BATTLES OF THE FLEET.

Aside from the moral qualities of the *personnel*, which constitute the prerequisite of success, there are five main factors on which the result of a battle depends—the construction and equipment of the ships, the artillery, the torpedo, the ram, and speed.

The torpedo and the ram have not been used in the late war, for the reason that the hostile ships have never come close enough to each other. It is claimed, it is true, that two Spanish torpedo-boats attempted an attack at Cavite on May 1. But these two vessels were so entirely covered by the rapid-fire artillery of the Olympia, even at a distance of 2000 meters, that they could only save their crews by running ashore as fast as possible. It is doubtful whether they were really torpedo-boats. If so, the attack could only have been made owing to entire inexperience with torpedo-boat attacks and complete ignorance of modern rapid-fire guns.

The other two factors, artillery and speed, have proved to be of much more essential and indeed of a very powerful effect. The superiority of the American artillery as to number, caliber, and kind of guns is well known. The general opinion is also that the shooting of the Americans was very good, while that of the

Spanish was miserable. This was the more essential for the Americans at Cavite, owing to the fact that a large number of their shells did not explode. If nevertheless they achieved such a complete success and caused such destructive fires, it was because of the comparatively large number of hits; there were still quite a considerable number of shells that did explode. Even as early as at the bombardment of San Juan it was discovered that many of the shells did not explode; but this fact was most noticeable at the naval battle of Cavite. It is true that at the end of the battle all the Spanish vessels were under water to the upper deck, so that the really mortal injuries could not be verified; the parts above water showed a number of hits, and there is no reason for the assumption that the ratio of exploded shells to that of unexploded ones was essentially different in the lower parts.

The Reina Christina showed ten shots that had gone entirely through the vessel; the after smokestack had been torn down by the falling of the mainmast; no explosive effect could be noticed. However, the whole ship had been burned out, which made accurate observation difficult.

The Castilla showed considerable explosive effects. The smokestacks and metal bulkheads of the upper deck were pierced in different places by fragments and splinters. The conning bridge and superstructure deck were completely destroyed and torn down.

On the Don Antonio de Ulloa the masts were pierced in several places; a 5.7-centimeter shot had gone clear through a 12 centimeter gun shield; the chart house and the starboard side aft showed two hits each, in which there had been failure to explode.

The Don Juan de Austria was burned out; effects of firing could not be observed.

On the Marquis del Duero the tube of the 12-centimeter starboard gun was bent upward; the cause of this could not be ascertained. Two shots had pierced the ship's side. The upper edge of the smokestack had been indented by a projectile. No splinter effects were noticeable.

On the General Lezo the demolition of the smokestack was apparently due to an explosion.

The Isla de Cuba showed no injuries.

On the Isla de Luzon the 12-centimeter forward gun, with its whole pivot and shield, had fallen over backward in firing. Two shots (presumably 4-centimeter) had gone through the bow; one of the masts had been grazed by a small-caliber shot. The engine telegraph and superstructures had been demolished; the helm upturned by splinters.

On the Argos nothing could be observed.

The Velasco had the foremast pierced and slightly burned, the mainmast torn down, and the anchor stock shot off.

When the American fleet advanced for the attack it was fired upon by a battery at Manila. The Olympia answered with two shots; both shells were afterwards found unexploded near Luneta. The governor's house at Cavite also showed a shot without explosive effect.

In this respect better results appear to have been achieved at Santiago. This may be gathered from the details known, although the reports refer only in a few instances to the explosive effects attained; but even here a number of cases of nonexplosion have been noticed on the Spanish ships, as well as the fortifications.

The following table gives some data concerning the hits in the naval battle of Santiago:

AMERICAN GUNS.

	American designation.							
	1-pdr.	6-pdr.	4-in.	5-in.	8-in.	12-in.	13-in.	Total.
Caliber, in centimeters	3.7	5.7	10	12.7	20	30	33	...
Number of guns on board	22	84	6	12	32	6	8	170
HITS.								
Maria Teresa	1	17	1	4	3	2	..	28
Almirante Oquendo	..	46	6	3	7	..	..	62
Vizcaya	..	11	4	6	45	..	..	66
Cristobal Colon	..	5	..	2	..	..	..	7
Total	1	79	11	15	55	2	..	163

This is not quite 1 hit per gun, or, leaving out the 1-pounders, which have only a short range of fire, 9 hits to 8 guns.

The Iowa is the only ship that has 10-centimeter guns, the Brooklyn the only one having 12.7-centimeter guns. These data can not lay claim to absolute accuracy, owing to the extent of the destruction. The calibers of the hits also admit of some margin.

Special mention should be made of the following points: The fallen foremast of the Maria Teresa showed 2 hits; 10 hits from 3 ships went into the smokestacks.

On the Almirante Oquendo a 20-centimeter shell went through the forward turret roof, exploding, and killing the whole crew in the turret. If the turret had had no roof the shell would have passed over it.

The superstructures on the deck of the Vizcaya had been almost completely destroyed by the end of the battle. Whether the torpedo which lay ready for firing in a bow launching tube was detonated by a hostile projectile could not be definitely established. It has also been said that the forward ammunition magazine had exploded.

A 20-centimeter shell hit the protective shield of the second 14-centimeter gun of the Maria Teresa, exploded in the rear of it and killed and mutilated everyone in the vicinity, as did also another shell of the same kind which struck the battery deck aft. Still farther aft two 30-centimeter shells struck so close together that their shot holes were merged into one. Explosive fragments from them had torn a hole 4 feet square in the ship on the opposite side (starboard).

The Christobal Colon, although having received but seven shots, gave up the game, seeing that there was no possibility of escape, as even the Oregon and Texas had caught up with her after a three hour's chase.

In no case has an armor belt been pierced. The greatest destruction comparatively was wrought by the 5.7-centimeter projectiles, while the efficacy of the 3.7-centimeter projectiles was very small, their range not exceeding 2000 meters. They are therefore to be done away with, perhaps a little overhastily, since they were constructed primarily as against torpedo-boats and for use at comparatively short distances.

In connection with the hits, a few figures as to the consumption of ammunition may be of interest, while the total consumption of ammunition is not yet known. Smith, a seaman on board the Iowa, fired 135 aimed shots from a 10-centimeter rapid-fire gun in fifty minutes. During the same period of time two 5.7-centimeter guns of the same ship fired 440 shots. The Oregon used in all 1,775 shells, but 1,670 of this number were used for the twenty 5.7-centimeter guns alone (or perhaps only for the ten of

one side of the ship), while the four 30-centimeter guns fired 31 shots.

The American material has demonstrated not only its efficacy but also its durability, as only four guns were in need of repairs at the end of the war, in all of which projectiles had burst in the bore. This fact, taken in connection with other frequent failures of fuses, shows that the construction of the fuse in America is still far from perfect.

It is well known that the extensive fires on board the Spanish ships were due principally to the fact that the Spanish had not sufficiently considered modern experiences and principles by removing everything combustible from the ships. One circumstance should be mentioned in this connection which has perhaps not been fully appreciated, namely, the danger of wooden decks with pitch in the seams. The danger of these decks was still further increased in the Spanish ships by the circumstance that the planks were not even resting on an iron deck. An iron lining excluding the air and being a conductor of heat naturally decreases the danger of a fire spreading, though it does not obviate it, as the splinters of exploding projectiles pierce the deck, thereby causing drafts of air from below. On the Maria Teresa, Almirante Oquendo, and Vizcaya the upper decks and all the woodwork were completely burned, other decks partially.

The Americans had avoided all combustible material in the construction and equipment of their ships; and moreover, special orders were given at the beginning of the war that all the ships should be examined and everything combustible that might have been left or accumulated on board through carelessness should be removed. Besides, the Spanish appear to have relied entirely on their steam pumps and water mains for extinguishing fires. When these had been destroyed or injured by hostile projectiles they had no other means to fall back on. Even the most primitive means for fighting fires, such as fire buckets and tubs filled with water, are indispensable in connection with our modern fire-extinguishing equipment which is very effective indeed, but also very complicated.

The thick powder smoke sometimes suffocated the Americans and almost blinded them. They sought to remedy this by tying wet cloths over their heads with small holes cut into them for the eyes. Smokeless powder would probably have had still more troublesome effects.

The range-finders, to which the good-firing results of the Americans were often attributed in the beginning, were not of much use. Owing to their delicate construction, their usefulness was soon impaired. The distances were then estimated from the height of the masts of the hostile ships.

While the Spanish were inferior in every other respect, they might have averted the whole sad catastrophe of Santiago by preserving and taking advantage of their greater speed, which they had shown, at least, at the trial trips of their ships. In this respect the Americans were at a great disadvantage from the outset.

The speed of the two armored cruisers, New York and Brooklyn, was superior by 1 knot to that of the Spanish cruisers, but these were the only ones; the speed of all the other vessels was inferior by from 2½ to 5 miles. The American ships, aside from previous services required of them—the Oregon, for instance, had not reached Key West on her return from San Francisco until May 26—had been blockading Santiago for five weeks. Their boilers were in constant use and could not be properly cleaned; the bottoms of the ships were badly fouled. It is claimed that in order to make 11 knots an hour the ships had to use as much coal as they required to make 16 knots, when in good condition, and even then they could not attain their original speed. The Spanish, on the other hand, had a good opportunity during their six-weeks' stay in Santiago harbor to put their boilers and engines in first-class condition and to clean the bottoms of the ships.

Here, again, the moral qualities of the *personnel* are of the greatest importance. Technical perfection is but an auxiliary in warfare—a o which acquires value only by the figure placed before it, namely, the mental qualities of the warrior. It is doubtful, however, whether the Spanish ships ever actually possessed the speed officially claimed for them. At trial trips it is easy enough to use means by which the efficiency attained appears greater on paper than it is in reality, especially if the *personnel* accepting the ship is not of the highest moral and technical standing. In any event, the Spanish engine *personnel* was not equal to its task.

It did not need this war to establish the value of an efficient engine *personnel* for success in war; but the immensity of the catastrophes must make it plain even to the most superficial mind

that it would be very wrong to deny the importance of the services of the men who give life and motion to the ship by the most arduous kind of work simply because they do not handle shell and lanyard, but coal shovel and fire hook. The very best of human material, strong in body and mind, is the only kind suitable for this work, and a navy should spare neither trouble nor expense to secure it.

On the subject of the efficiency of monitors opinions in United States naval circles were much divided at the beginning of the war. The North Americans are the only ones who still continue to build this type of ship. Little has been heard of their services during the war. Two of them went from San Francisco to the Philippines, the greater part of the way in tow of their colliers. The Monterey, accompanied by the collier Brutus, left San Diego, Cal., on June 11 and arrived at Manila on August 4. The distance is 7600 miles, 3725 miles of which she was towed. Twice she had to touch at anchoring places, namely, at Hawaii and Guam. She was towed from the 8th to the 23d of June, 712 miles; from the 5th to the 22d of July, 2541 miles, and from the 25th to the 28th of July, 472 miles; average speed while in tow, 6.76 knots. The weather was fine during the whole time, with the exception of a slight storm on July 31. The voyage took in all two months less seven days. The Monadnock took exactly the same length of time, having left San Francisco on June 23 and arrived at Manila on August 16.

These voyages are quite remarkable as far as sea efficiency is concerned, but when it comes to war efficiency they had better not be relied upon. The confidence in the efficiency of the monitor for war purposes has been considerably shaken. Captain Mahan, who used to argue in favor of a defensive navy composed of monitors, has recently expressed the opinion that the inefficiency of the monitors had now been proved; that they had been a constant impediment to the fleet owing to their lack of speed, limited coal capacity, and unstable platforms, which completely excluded effective firing in a bombardment. For harbor defenses also he prefers land fortifications to monitors.

II. Bombardments.

What might be the results of a serious battle between armorclads and coast forts the war has not demonstrated. The Ameri-

cans in these instances have never gone close enough to make it possible to note decisive results on either side of the belligerents. They should not be blamed for this. If they could obtain their object without taking greater risks, it would have been a mistake to take such risks, and they certainly did attain their object. The great injuries, however, which the Americans claimed to have inflicted at different times have subsequently proved to be exaggerations and delusions. Even at target practice we believe only reluctantly the statements of "too short" or "too far" made by an observer favorably stationed. The claims that the forts had been silenced, which would presuppose that the guns had been dismounted, were also founded on delusion.

There is no doubt that the Americans had better guns than the Spanish in their land batteries and could fire at distances which the Spanish guns could not reach. When this was recognized ashore and the firing stopped, the ships thought they had silenced the batteries. It has therefore been demonstrated that the ships were unable to seriously injure the land fortifications at great distances. After all the bombardments of Santiago there was but one gun dismounted in each of the batteries at the Morro and the Socapa. It has not been demonstrated whether with equal armaments and skill in firing on the part of the Spanish the ships would not have seriously suffered. Still less has it been demonstrated what the relative situation of the belligerent parties would have been if shorter distances had been chosen.

The employment of torpedo-boats for bombardments, as at Cardenas, must be designated as entirely unsuitable. Torpedo-boats are expensive and delicate vessels, equipped for launching torpedoes and for great speed. Their guns are intended to be used only in extreme cases. When the torpedo weapons can not be used their other principal quality, speed, in connection with the circumstance that they draw little water, may be utilized for the transmission of orders and information; but bombardments, even in narrow and shallow waters, had better be left to the most primitive gunboats, etc.; they can do better work and are less expensive, but can never take the place of a disabled torpedo-boat.

The so-called dynamite cruiser, Vesuvius, was a failure. Her projectiles can be fired only at medium and short distances, and cannot be aimed. The terrible effects claimed for hits can not

be considered as counterbalancing this. It is true that an accidental hit may cause great havoc, but in this age of accurate firearms we should no longer reckon with such uncertain factors. The Americans have utilized the vessel accordingly. They used to send her at night against the coast defenses, counting on accidental hits, while the vessel, protected by the darkness, did not betray her presence by any flash at the discharge nor by smoke or detonation. Nothing has been heard of any particular result. No attempt was made to carry out the idea, so much talked of at first, of destroying the mine obstructions by systematic bombardments of the harbor entrance. In order to do this it would have been necessary for the vessel to approach the shore in daytime, when she would have been exposed to the very dangerous fire of the coast forts, and a systematic bombardment could hardly be spoken of in view of the uncertainty of a fire.

The Americans consider this vessel a failure, as also the ram Katahdin, which, aside from four rapid-fire guns, has no other weapons but her ram.

III. Coast Defense.

Some obstructions by means of vessels and mines were laid out by both belligerents, but have not come into play. The Spanish had attempted to close the entrance of San Juan Harbor in Porto Rico and that of the Pasig River at Manila by sunken vessels. In the latter case it was the opinion of German officers that it did not constitute a military obstruction, although it interfered considerably with the movements of shipping.

The two mines which were blown up in front of the Olympia at the beginning of the battle of Cavite were not intended as a regular obstruction of the channel, but represented ony a small mine field for vessels that might accidentally pass over them. They were fired prematurely.

In the entrance of Guantanamo Bay the Americans found quite a number of mines. These might have caused considerable damage if they had operated, for the Americans entered the bay without any precautionary measures, and the screws of the Marblehead tore two of the mines loose from their anchorages so that they rose to the surface of the water. Then the whole bay was systematically searched for mines. This was done on June 21 by the boats of the Marblehead and Newark. Four steam

launches, under the fire of Spanish infantry hiding on the shore, fished up thirteen mines on the first day with light chains they were towing. The ships, of course, fired on the hostile position, which was soon abandoned. During the next few days thirty-five more mines were found and taken ashore. These proved to be charged with 120 pounds of gun-cotton each. Many of them showed evidences of having been in contact with ships' bottoms or screws, but the firing mechanism was not capable of operating. The fuses showed such grave defects that it was quite evident that the work of constructing them had not been done under the supervision of a superior.

The mines raised in Santiago Harbor after the surrender of the place proved on the whole to be in better condition. Still, the outer row containing contact mines was of doubtful value. One mine was found, for instance, in which half of the gun-cotton had been burned, leaving no doubt that it had been in contact with some object—probably the Merrimac—and that the fuse had acted, but that the gun-cotton charge had become spoiled.

The second row of mines (electric) was in pretty good condition and might easily have destroyed one or more ships if an attempt had been made to force the entrance. These latter mines contained a charge of 200 pounds of gun-cotton each. All the mines in Guantanamo as well as Santiago Bay were thickly overgrown with barnacles and seaweeds.

As a curiosity, it may be mentioned that lightning struck an American mine in the lower Mississippi and exploded it, and that several mines in the Potomac were exploded by lightning at a few seconds' interval without causing any disturbance in the rest of the mine system. They blew up exactly as it was intended that they should be blown up in war.

IV. Blockades and Cruiser Warfare.

Both of these were applied by the belligerents in the mildest possible form. Spain can hardly be considered in this connection. She could do no blockading, and it is somewhat doubtful whether it was quite voluntarily that she abstained from capturing hostile merchantmen. The Americans were enabled to maintain quite an effective blockade on the coasts, which they designated as blockaded, by means of the large number of yachts and other steamers which they had incorporated into their navy as

auxiliary vessels, while their large ships were giving their attention to the hostile naval forces.

It can hardly be said that the Americans carried on systematically any destructive warfare as against Spanish merchantmen. Those they did capture almost ran into their hands, so to speak. This was especially the case at the beginning of the war, mostly with vessels which, owing to the usual Spanish carelessness, had received no warning of the fact that hostilities were about to break out. This was even the case with the Spanish gunboat Callao in the Philippines. Still a few prizes may be mentioned which were captured while making a direct attempt to run the blockade, also a few cases where vessels were chased till they ran ashore, while a few fast Spanish vessels succeeded in running the blockade. But neither the successful nor the unsuccessful attempts at running the blockade were of much importance.

A number of neutral vessels were also captured, but nearly all of them were released again, for the American Government, in adjudicating their cases, showed a liberality which was quite unheard of in former naval wars and which probably had a political background. About thirty vessels in all were considered good prizes.

As the United States as well as Spain have refrained from privateering, although they were the very countries which reserved that right at the time of the Paris declaration, it may be assumed that privateering is definitely at an end.

During the blockade of Santiago the harbor entrance was at night kept constantly under the light of the projector of some ship designated for the duty and boats were stationed at intervals between the other vessels and the shore, so that any attempt of the Spanish ships to go out might at once be perceived. It has been commented upon that the ship so illuminating the harbor entrance was hardly ever fired upon by the fortification works. It would seem as though telegraphically connected observation stations at the Morro and Socapa could have ascertained the exact distance of the troublesome watcher and made her work, if not entirely impossible, yet extremely difficult by firing upon her.

V. Landings.

The landing of the Americans at Daiquiri is the largest landing effected since that of the western powers at Balaklava in the

Crimean war. Yet the total forces landed did not exceed 15,000 men, embarked in fifty-three steamers. It took a long time before the troops were ready to start, for everything required for an army and a landing had first to be procured. When the expedition finally did start it was found that a great deal had been overlooked or was incomplete, or had been lost in the chaos, or could not be secured. For instance, no cavalry horses—except for one troop—could be taken along because there had not been time to fit out the vessels for the reception of horses. The voyage and the landing were effected in the most beautiful weather; the Americans had good luck, as they always did. The forces were landed unmolested.

The disembarkation was effected almost entirely at a small landing bridge where but two boats could go alongside at a time. Attempts to have boats run ashore on the small sandy beach, at one end of which was the bridge, had to be abandoned after the loss of several boats, which were wrecked in the surf on the projecting rocks and stones. The report that the United States warships had first fired on the open strip of land back of the landing place and routed the Spanish should not be taken literally. No such open strip of land exists there. The rocks reach close to the sea, offering hundreds of sheltered places from which the bridge might have been fired upon. Authorities in military matters state that 300 men, though they might not have been able to prevent the landing entirely, could have caused great losses. But on this occasion, as on so many others, the Spanish showed that they had no appreciation of military situations, and as soon as the bombardment commenced they retreated. They need not have paid much attention to the Cubans. The Spanish ought to have known that now that the Americans had arrived the Cubans would avoid danger even more than before.

With the landing of the army all operations on the part of the Americans ceased for a while. In spite of the most exhaustive use of all the boats and auxiliaries of the warships, including the armor-clads guarding the entrance to Santiago Harbor, it took several days before the field guns and luggage could be brought ashore, to say nothing of the siege guns. It was found that there ought to have been many more lighters, especially such as are equipped with lifting apparatus. There was only one of these—a second one had disappeared during the voyage. There were no

devices for landing horses and mules which were intended for drawing the guns. The animals were hoisted overboard, and it was taken for granted that they would swim ashore. But in a number of instances this did not happen. Many of the frightened and bewildered animals swam out to sea and were drowned. As all the boats were being used in the landing and were crowding each other for hours at the landing place, there was none available to go after the mules and lead them in the right direction. The few men in charge of landing the animals had all they could do to get those that swam ashore out of the surf and in safety. About 50 animals perished.

There was lack of management generally. No one in authority had been appointed commander of the landing place. The commander-in-chief, General Shafter, did not trouble himself about the landing. Admiral Sampson had only made arrangements as far as the warships and their boats were concerned. The only landing bridge was but partly covered with loose boards. No material nor tools were at hand to build other bridges, and little attention was given to the one bridge in existence, as is evidenced by the fact that three weeks later the loose boards were still loose.

The conditions at Siboney, where part of the troops and supplies were landed a little later, were quite similar, except that there was no bridge at all. But in calm weather a few boats could be run ashore side by side. No bridge was built here for the landing of the voluminous luggage.

The relations between the military authorities and the officers of the transport steamers had not been regulated. The latter had only their own advantage and that of the ships' owners in view, and did not pay the least attention to the wishes and plans of the officers of the troops. The greater part of the time they kept at a distance of from 3 to 20 miles from the shore, to make sure not to go too near or to get into collision with other vessels, and if at times they did assist in unloading their cargoes, they would return to the sea as fast as possible as soon as fire was opened ashore, often taking with them the most indispensable articles of the army equipment. An American reporter even calls them insolent, un-American, mutinous cowards. The army authorities were unprepared and powerless before such conduct on the part of the officers of the transports. Under these cir-

cumstances it is not strange that the landing of the provisions, guns, and ammunition, and the entire equipment, all of which were so much needed in this locality, which offered no resources, was effected with such slowness that the troops were reduced from the outset to the meager rations which each man carried with him, and where these had been thrown away, as had been done in many instances in order to lighten the weight, the soldiers suffered hunger.

VI. Coaling.

The late war will give a new impulse to the important question of supplying coal. Ships and fleets carrying on war in a region where they do not have available bases of supplies and coal depots in their immediate vicinity, or whenever they are not certain that there may not be occasion for their having to leave such region temporarily, should have their own colliers along. The colliers should have the same speed as the squadron. The ships should not be compelled to rely on rendezvous or the uncertainty of colliers sent after them. But not only should care be taken to have a sufficient supply of coal, but also to provide appliances for taking coal on board under all circumstances in the shortest possible time. The lack of such appliances has contributed not a little to the disasters of the Spanish. The coaling of Admiral Camara's ships at Port Said was nothing but a comedy. Admiral Cervera intended to coal rapidly at Santiago and proceed. But the appliances for that purpose proved so defective that the United States fleet had shut him up in the harbor before he could finish coaling, which operation took several days. At present not many ships are being built with that end in view, nor are they being equipped with appliances for coaling in the shortest possible time. This will be absolutely necessary in future, so that the ships may be enabled to take on coal or other fuel either from a wharf or from a lighter or collier at sea.

VII. Auxiliary Warships.

What can be done with money and a practical mind in the matter of securing naval war material the Americans have done since the war cloud first appeared on the horizon. It is true that the purchase of foreign warships before the beginning of the war proved almost a failure. The United States bought the fol-

lowing Brazilian warships: The protected cruiser Amazonas, of 3,450 tons, afterwards called the New Orleans; the protected cruiser Almirante Abreu, same size, afterwards called the Albany, and the cruiser Nictheroy, of 7,080 tons, afterwards called the Buffalo, which, aside from her good rapid-fire armament, had a 38-centimeter dynamite gun; from other sources, the cruiser Diogenes, of 1,800 tons, renamed the Popeka, and a torpedo-boat purchased in Germany, called the Somers. The only ones of these that were assigned to the active fleet were the Topeka and the New Orleans. The Albany and the torpedo-boat Somers, which were still in England after the breaking out of the war, were not allowed to leave there on account of England's neutrality. The Buffalo did not leave the navy-yard during the war. The United States had better luck with the merchant steamers they purchased and converted into auxiliary cruisers and gunboats.

They bought 60 yachts and other steamers as auxiliary gunboats and scouts, 4 large fast ocean steamers as auxiliary cruisers, 11 tugs, subsequently armed. The following were chartered: Four large ocean steamers as auxiliary cruisers. Placed in commission: Fourteen revenue cutters as auxiliary gunboats and scouts. In all, 93 steamers for warlike actions, more or less armed and fitted out for that purpose.

There were also purchased as adjuncts of the fleet 20 transport vessels, 9 colliers, 1 repair ship, 2 water-distilling ships, 2 ice-manufacturing ships, 3 hospital ships; in all, 37. This does not include the temporarily chartered steamers for the larger troop transports.

The large auxiliary cruisers were also occasionally utilized for the rapid transportation of troops. The auxiliary gunboats were indispensable for the blockade of the extensive stretch of the coast. The names of several of these, even of tugs, have been specially mentioned in several of the battles. A few of the auxiliary vessels, as, for instance, the St. Louis and the Zafiro, were equipped with special devices for dragging for cables, which they have used with good success.

As for the adjuncts of the fleet, the distilling ships were intended especially to furnish fresh water to the blockading auxiliary vessels and the transports of the landing army. As most of these vessels had inadequate distilling apparatus, some of them

none at all, this was necessary, so that they might not be compelled to leave the blockade for the purpose of renewing their water supply. The repair ship Vulcan was also equipped with a powerful distilling apparatus.

The ice-manufacturing ships supplied the vessels not equipped with ice machines, also the hospitals of the invading army of Cuba. The object of the other adjuncts of the fleet is self-evident.

The repair ship Vulcan has proved extremely useful, even indispensable for the blockading fleet at Santiago. She supplied 31 vessels with extra engine parts, material, and tools. Twenty-six vessels were repaired, and a number of repairs were also made on guns and their equipments. The Vulcan also rendered important services in connection with the raising of the Maria Teresa and is now doing the greater part of the work in temporarily repairing said ship for the purpose of transferring her to one of the United States navy-yards.

How important it is to own transports specially fitted out for the transportation of troops and war material has been demonstrated in this war, though principally by the lack of vessels equipped for such service. Of the transports purchased during the war, the Navy Department intends to retain 16, which are to be refitted for service as regular marine transports, namely, the Panama, Port Victor, Rita, Mohawk, Mobile, Massachusetts, Manitoba, Minnewaska, Mississippi, Michigan, Roumania, Obdam, Berlin, Chester, and Britannia, employed on the Atlantic ocean, and one on the Pacific coast. During the war they were used not only for the transportation of troops, but also for supplying provisions and material.

It would have been very desirable to have had even more of these. The blockading fleet, for instance, complained of the very defective mail service, as also of the fact that, although it was comparatively but a short distance to the United States ports, so few fresh provisions were received, which circumstance impaired the health of the troops.

Vessels built for special purposes are in times of peace, at maneuvers, stepchildren of the Navy; they are considered expensive and troublesome adjuncts which have to be taken into consideration in maneuvers and impede their rapid execution; and yet how useful they are and how much relief they are able to furnish in

actual war! Whenever mobilizations show that there is not a sufficient number of suitable merchant steamers which would be unquestionably at the disposal of the Navy at the beginning of a war, provision should be made to have vessels set apart which can be easily equipped for such purposes, and, if necessary, to own and keep in constant readiness a number of such special vessels even in time of peace.

The next number of the Institute Proceedings, issued the last of March, will contain the following articles:

THE ST. LOUIS AS AN ARMY TRANSPORT.

By her Commanding Officer, Captain C. F. Goodrich, U. S. Navy.

THE LAST NAVAL ENGAGEMENT OF THE WAR.

By Lieutenant W. F. Halsey, U. S. Navy.

THE COAST SIGNAL SERVICE.

By Lieutenant F. B. Anderson, New York Naval Militia, who was on the Board to organize the Service.

SOME EXPERIENCES ON A TUG BOAT DURING THE WAR.

By Ensign W. S. Crosley, U. S. Navy.

SEAVEY'S ISLAND PRISON AND ITS ESTABLISHMENT.

By Paymaster J. P. Loomis, U. S. Navy, who was the moving spirit in establishing and maintaining the prison from the Commissary's standpoint.

THE HYGIENE OF THE NAVY RATION.

By Surgeon H. G. Beyer, U. S. Navy.

RANGE OR DIRECTION INDICATOR.

By Lieutenant Armistead Rust, U. S. Navy.

Beginning with the next number the binding of the Institute Proceedings will be changed to a more attractive form.

Throughout the year articles and discussions on the war will appear, and it is the intention to get the best papers.

It is the desire of the Board of Control to increase the interest of the Service and the public in the Institute and its work.

To this end the aid of the members and friends is solicited.

PROFESSIONAL NOTES.

RUSSIAN VIEWS OF OUR WAR.

Admiral Makaroff's Views of the Lessons of Santiago.

Rely on Your Guns—Never Sacrifice Artillery to Armor—The Sword Always Mightier Than the Shield—A Victory Exacts the Same Conditions on Land and Sea.

(From the St. Petersburg Kotline.)

The destruction of Cervera's ships at Santiago has again brought to the front the question, Should the principal force of a fleet consist in armored or unarmored vessels? If under the name of cruisers are classed vessels of light artillery intended to prey upon the commerce of the enemy, the only possible answer is that armored vessels are preferable to cruisers. An enemy never considers himself beaten because his commercial fleet is captured. For each ton of armor from four to five tons displacement will be necessary. Consequently a ship carrying an armor of 2000 tons would require a displacement of 600 or 800 tons more than that of an unarmored cruiser having the same speed and radius of action. Consequently, battleships must always be large, while the dimensions of unarmored cruisers may vary all the way down to those of torpedo boats. There is no advantage in making unarmored vessels very large, because it is, of course, impossible to utilize all their displacement for their artillery. They must have powerful machines and must carry an enormous supply of coal. It would not be difficult to construct an unarmored vessel of 3000 tons, carrying one gun of 25 centimetres and five guns of 15 centimetres, and having a speed of twenty-one or twenty-two knots, with the machinery, the boilers and the magazines sufficiently protected. But, if we are asked which is the more powerful as a unit in combat, a battleship of 15,000 tons or an unarmored vessel of 3000 tons, the reply, of course, must be in favor of the armored ship. If, on the other hand, the question is whether it is more advantageous, for a determined sum, to build one warship of 15,000 tons or four armored vessels of 3000 tons, the answer can no longer be in favor of the battle-ship.

All the writers who have dealt with this question, with the exception of Lieut. Engleman, have pronounced for the battle-ship.

Now, let us look at the lessons that we can derive from the battle of Santiago. We find there that the two adversaries were supplied with armor and modern guns of both heavy and light calibre. In reality there is not a line of demarcation well traced out between the cruiser and the battle-ship. The Iowa and the other Armerican ships are called battleships, but they possess only a limited supply of armor plates, the thickness of which at the water-line is 355 millimetres, and a surface protection of 186 feet. Three of the Spanish cruisers, the Infanta Maria Teresa

and two others of the same type, had armor of 305 millimetres in thickness at the water-line and 315 feet of surface, but of less width than that of the American ships. Upon these cruisers the barbettes, armed with cannon of 21 centimetres, were protected by a *cuirasse* of 255 millimetres. The Iowa, with a displacement of 4500 tons more than the Spanish cruisers, also had her guns protected, but by an armor of only 100 to 200 millimetres, an utterly insufficient protection against the projectiles of cannon of 28 centimetres.

The cruiser Cristobal Colon had an armor of the recent type, protecting nearly three-fourths of her surface and sheltering even her small guns. Her displacement, it is true, was only 7000 tons, utilized for the most part by her armor; that is to say, the artillery was sacrificed for the sake of the armor. Nevertheless, the Cristobal Colon had two Armstrong guns of 25 centimetres and forty calibres in length and of the most recent type. Her projectiles should have pierced the armor of the American vessels in ordinary conditions of combat.

Each one of the two parties engaged, therefore, was provided with armor, and with guns sufficiently powerful to pierce it. The extent of the unprotected surfaces was greater on the American side. The Americans had a numerical superiority. Nevertheless, the victory might have gone to the other side or, at all events, have been dearly bought by the victor. If, in the battle of Santiago, the Spanish projectiles did not strike the American fleet, it is not to the armor that the latter should attribute its victory, but to the accuracy of its fire, and the quality and order of its shots.

We do not know if the Spanish ships practiced firing much in time of peace, but after all, that sort of practice is nothing compared to what is had in actual warfare. The journals which every day gave us accounts of the bombardment of Spanish forts by Admiral Sampson and Commodore Schley were silent upon the operations of the artillery of Admiral Cervera.

From a moral point of view the two fleets were diametrically opposed. The Americans were seeking a combat and had entire confidence in their artillery. The Spaniards, under the pressure of orders from Madrid, came out of Santiago with the absolute certainty of meeting the disaster that awaited them. In this passive rôle they could only count upon their armor and their speed. The speed did not come up to the power of the machines on account of the poor quality of the coal and the growth that covered the immersed portions of the vessels, and, perhaps, also to the inexperience of the machinists. There remained, therefore, only the armor, which inspires so much confidence in the minds of so many people and is supposed to protect a vessel, leaving out all other elements, material or moral. There was no reason why that protection should not exist in the battle of Santiago; nevertheless it was not sufficient for the Spanish fleet.

At Lissa the armor did not prevent the Re d'Italia from sinking or the Palestro from blowing up. At the battle of Yalu it did not save the Chinese fleet; neither did it prevent the Chinese cruisers from being sunk by the Japanese torpedo-boats at Wei Hai Wei.

We are, therefore, brought to the conclusion that in a naval battle it is better to rely upon the strength of the weapon rather than upon the solidity of the shield. Put more artillery and torpedoes on board your battle-ships, arm them with solid rams (*éperons*) and reject the idea of pro-

tecting them with armor, because that does not assure the victory; it only retards the defeat. Such a small result does not warrant the construction of vessels overloaded with armor.

(*From the Invalide Russe.*)

In our opinion Admiral Makaroff clearly explains the fundamental cause of the Spanish disasters on sea and presents sound views of what should be expected from modern fleets. It never enters into the minds of landsmen when dealing with a military engagement to seek the causes of defeat in the thickness or the height of the earthworks of one or the other of the two adversaries. We know that the decisive attack is prepared by an intense and accurate infantry and artillery fire, and that the exigencies of victory require a thorough preparation for a hand-to-hand fight. Although the armor of warships, sheltering their vital parts, is of far more importance than the intrenchments of land forces, a naval combat exacts the same material means of attack and the same moral qualities as a land battle. On land the preparation depends especially upon the infantry fire; on sea, of course, the artillery plays the principal part, and the intensity of the shock is measured by the distance between the fighting vessels.

Consequently a powerful artillery with trained gunners is the principal essential, to which must be added sufficient speed to approach the enemy or avoid the combat. Of course there should be a reasonable protection against the projectiles of the enemy. To present these conditions in another order, that is to say, to sacrifice the artillery or the speed to the *cuirasse*, is simply to disarm and invite destruction. Armor rarely saved a fleet, and it never gave one a victory. The last naval wars have proved this conclusively. The victory belongs to the attacking party on sea as on land.—*New York Sun.*

LESSONS FROM THE BATTLE OF SANTIAGO.

Since we discussed the information received as to the facts of the destruction of the Spanish cruisers by the American fleet, fuller accounts have come to hand. We may especially mention the official diagrams of hits made on the Spanish vessels, given in the *Scientific American* of September 10th, and the accounts of two correspondents who were eye-witnesses of the fight, one from the deck of the Brooklyn and the other from that of the New York, published in *McClure's Magazine* for September. These we do not propose to review in any sense, although we are making use of information obtained from them in forming the conclusions which we think are to be drawn from the character and occurrences of the fight.

First, a few words as to the actual conditions of action. The correspondent on board the Brooklyn was probably exactly in the best position to see and report the progress of the engagement. We may remind our readers that the Spanish ships steamed out of the harbor towards the west in succession, passing the west end of a line of United States men-of-war blockading the harbor. The Brooklyn, lying at the west end, was thus best placed to pursue the Spanish ships, both because she had some start as to her position, and also because she had the highest speed of any ship in both fleets. Mr. Graham's account is spirited and graphic,

though here and there rather too florid for professional readers. No naval officer, for example, could accept the statement that "the situation for the Brooklyn now seemed desperate," because the Spanish cruisers were running towards her. She had the overpowering strength of the United States fleet with her. She had, no doubt, to avoid exposing herself to being rammed, which she apparently very easily did by turning her head to starboard, so as to circle round with her stern towards them. She fired one broadside from her port guns, but she necessarily lost ground in going to meet the Spanish ships, who must have gained on her as she circled. Certainly the United States fleet got under weigh with admirable promptness; but we must pass on to our discussion of the effect of the fire as a whole, and the lessons to be drawn from it. The curious fact is to be noticed in passing that the Spanish ships, whose object was to escape, and who would certainly have benefited by smoke to conceal them, used smokeless powder; while the United States ships, who were endeavoring to pour in as accurate and rapid a fire as possible, were much hindered by the fact that they had not smokeless powder. No doubt the evil was modified by the speed at which the ships were running, and it appears that officers were sent aloft on board the Brooklyn to tell the gunners the effect of their shooting. Probably the smoke would scarcely reach this height before it was left behind. Yet the directions seem to have been of a very general character, and the statement that "every shot is telling," while encouraging, was only correct if it referred to every shot that hit, for the large number that we know missed could hardly tell even morally on an enemy that was running from the Brooklyn; most properly so running, for it is absolute nonsense to talk as if the Spanish cruisers could do otherwise. When truth forbids us from crediting them with anything else, we must allow that the Spanish made a gallant attempt to get their ships out, and gave their lives lavishly to effect it.

To get an idea of the circumstances of the firing, we cannot do better than follow the account of Mr. Graham, on board the Brooklyn. Apparently the enemy next appeared as a dark mass through the smoke, and, after coming round, the Brooklyn attacked first the Maria Teresa and then the Vizcaya—generally from about a mile and a quarter to a mile and three-quarters range—till she turned in and ran ashore, and lastly the Brooklyn gave chase to the Colon, who had managed to show speed enough to have gained a lead of over three miles. The Brooklyn was only able to make 17 knots, because she had been unable to couple her forward engines, so that the Colon, who had the advantage of getting up her steam deliberately, ought to have escaped, had she been in fair order. To come, however, to the gunnery of the Spanish ships, the Maria Teresa and Oquendo, with no heavy guns, and only ordinary 5.5-inch guns, never had a chance of successfully running the gauntlet of the heavy battle-ships Texas, Iowa, and Indiana, which fired on them, though they had not the speed required to follow the cruisers far. The Oregon, indeed, was able to keep up well throughout. The Vizcaya for a time had mainly the Brooklyn to deal with her. Mr. Graham writes as if the Vizcaya ought to have been more than a match for the Brooklyn. She certainly had thicker armor, especially at her belt, but this could not prevent her other parts being destroyed by the greater fire of the latter. Had all the guns been complete, the Brooklyn's entire energy of fire per minute is about 192,032 foot-tons, against 179,203 of the Vizcaya. Probably the Brooklyn could bring to bear three of her four 8-inch, and

half of her twelve quick-fire 5-inch guns, giving an energy of 111,012 foot-tons per minute, against 107,625 foot-tons delivered by the Vizcaya's two 11-inch guns, and half of her ten quick-fire 5.5-inch guns. We fear, however, that the Vizcaya's heavy guns were non-existing, so she had only 71,580 foot-tons energy of fire, and, as a matter of fact, seems to have been able to deliver very little effective fire at all, partly from bad gunnery, and partly, perhaps, owing to injuries received in passing the slow battle-ships. Under these conditions the Brooklyn would be able to man all her light unprotected quick-fire guns, which we have not taken into account hitherto because men could hardly live at them in close action. Consequently the Vizcaya would be subject to all the Brooklyn could do, and in about twelve minutes the Oregon joined in and destruction rapidly followed, so that in six minutes she ran ashore hopelessly on fire. She had received five 8-inch, seven 5-inch, four 4-inch, and thirteen 6-pounder shells in all. The story of the Vizcaya is more or less that of all the Spanish cruisers, except the Colon, whose 6-inch plate protection to her upper structure and general condition put her in a very different position, and ought to have secured her escape had her speed been kept up. Their vital parts were protected by their belts, but they were destroyed by fire and wholesale cutting to pieces of their secondary parts and crews. This was effected mainly by the quick-fire guns, but few heavy gun projectiles going home, the above-mentioned 8-inch shells being the best performance. Apparently, the most important elements for success in a running fight, such as took place, are, first, speed; secondly, gun power; thirdly, power of resisting conflagration. The first requires little comment. It is a question of actual speed obtained in trial and of keeping the engines and bottoms of the ships in order. It is well to note that the notorious Huascar was eventually caught up and disabled only by cleaning the bottom of the Cochrane, and securing the slight superiority in speed that enabled the Blanco and Cochrane to overhaul the Huascar. We might indeed alter the old proverb, " For want of a nail the shoe was lost, for want of a shoe the horse was lost, and so the rider and kingdom," to read, for want of a cleaning the three knots were lost, for want of three knots the cruisers were lost. On the other hand, in virtue of a clean bottom some years ago Captain Kane was just able to withstand the wind that drove other ships on shore, and get his vessel safe out of Samoa Harbor. On the importance of our first point, then, namely, good engines and clean bottoms, we must all be fully convinced.

The second point is efficient fire. This seems to be best delivered in the form of heavy quick fire; that is, the fire of quick-fire guns mounted behind medium armor. This we have long insisted on. Leaving the question of conflagration till the last, so far as gun-fire was concerned, the Spanish gunners might have stood to their guns had they been in 6-inch casemates, for the American 5-inch quick-fire guns could not by any possibility have perforated them. As to the question of accurate shooting, whatever was the exact proportion of rounds that took effect, it is clear that the American officers found that they had considerable opportunity of testing their powers of shooting and improving it, in spite of some casualties, as they went on. We read, for example, of George Ellis deliberately measuring and recording the range in an exposed position, and his head being instantly afterwards carried away by a shot. The measure of success attained may have fallen short of what

we should hope from results of practice-firing; but however this may be, it is quite clear that accurate shooting was very desirable, and that the relative positions of any two ships engaged depended greatly on it.

Lastly, as to the incendiary action of the shell, this is a newer and more important point. Constructed as the Spanish cruisers were, primary attack of vitals was very difficult, and was not attained at all, we think. Secondary attack by quick-fire common shells practically settled the matter. How far is this of general application? Had the Spanish ships been built like the Germans, without wood anywhere, they could not have been set on fire. Are not the Germans right, and ought we not follow the same line? We specially have no doubt to keep in view the habitable character of our ships; but does not this action show us that wood must at all costs be given up? It seems strange that wood should burn as it does. We might explode loose powder on the floor of a room without setting it on fire. The fact is that a bursting shell drives large lumps of burning explosive into the wood, and once there, water would probably fail to extinguish it, seeing that it has its own oxygen incorporated in it in a solid form, and would burn freely under water. It seems hardly possible for a ship containing much wood to escape fire, especially under quck-fire attack, for a 6-inch or 5-inch shell would set a vessel on fire nearly as well as a larger projectile. Are we then to depend only on quick-fire? We think not altogether, for we can conceive the case of two ships blowing each other's secondary parts to pieces to a great extent, and yet remaining intact as to their vital or primary parts. Once this action is pushed far, it is clear that the vessel which perforates the other's thick armor best is likely to carry the day. Naturally, however, different classes of ships have their special functions. It is interesting to turn to existing types to see how they would have acquitted themselves at Santiago. The Esmeralda would, we think, have found the very work she is suited for. Her very high speed would have carried her rapidly away, and her tremendous fire would have made her very ugly to approach. On the other hand, we have repeatedly condemned the light pieces carried by the New York. It is curious that she should just have missed the opportunity of showing her powers.—*The Engineer.*

THE LIFE OF NAVAL ORDNANCE.

WASHINGTON, November 7, 1898.—The Navy Department has received reports from nearly all the war vessels which took active part either in the battles or the bombardments of the Spanish-American war. These reports show in detail the number of rounds fired from every gun on board, from 1-pound rapid-fires up to the big 13-inch rifles, and the Ordnance Bureau experts have examined them with much interest to note the condition of the guns before and after firing in order to estimate the probable deterioration resulting from the war service. The department officials are disposed to treat the figures of the reports as confidential military information not to be made public, but Captain O'Niel, chief of the Ordnance Bureau, and Professor Alger, ordnance expert and mathematician, have given the correspondent of *The Iron Age* some interesting information concerning the condition of the guns and the severity of the tests to which they were put during the war. In this connection Captain O'Niel said:

"Our reports show that our ordnance, from the smallest guns to the largest calibres, developed the highest degree of efficiency and little if any deterioration. I speak especially of the large calibre guns when I say that no evidence whatever has been found that the ordnance has developed any weakness. So far as I am advised not a single gun has shown any bad effects from the firing tests to which so many of them were subjected, and there has not been even a suggestion of drooping muzzles or other evidences of structural weakness. We have at no time expected that the severest tests would cause the muzzles of our long rifles to droop, as we have had every confidence that the guns were manufactured on correct principles. A drooping muzzle indicates, to my mind, poor construction based on a faulty principle. The British navy experienced some difficulty of this sort several years ago with a special class of guns that lacked the stiffness that should be possessed by first-class weapons, but the drooping of the muzzles of the guns referred to was due entirely to poor construction and improper design, and not to the result of firing more rounds than the guns should properly stand. We are much pleased with the manner in which our ordnance behaved, and believe that a great majority of our guns came out of the war in as satisfactory a condition as they entered it."

Professor Alger, who has gone into the subject in closer detail than Captain O'Niel, sad: "With the exception of the small rapid-fire guns, our navy rifles were not fired a sufficient number of rounds to weaken well-constructed ordnance. Even on the ships which took part in the bombardments the big rifles were fired only a few times, comparatively, and their total service during the war did not constitute any great proportion of the life of the modern high power gun of large calibre. While there is considerable difference of opinion on the point, I think it is safe to say that such a weapon as a 13-inch rifle, as they are constructed for our navy, may be fired from 250 to 400 rounds without showing any deterioration. Even then the gun does not become structurally weak. The first defect noted is the effect of the erosion of the tube near the base caused by the action of the powder gases. Sometimes this effect is seen in the erosion of a considerable area in the tube, which ultimately seriously affects the velocity and accuracy. When first developed at the base of the shell it can be remedied by using a larger metallic ring on the shell to secure a more accurate fit to the tube, but in some cases the erosion is so serious and affects such an area of the tube as to make the gun useless. Even then, it should be remembered, the gun can be retubed, although the process is somewhat difficult and expensive. If this operation is resorted to, however, I do not see why the life of the gun cannot be prolonged indefinitely. I believe the theory has been presented in the past that the constant firing of a gun tended to crystallize the metal composing it, thereby rendering it liable to burst. I do not think that modern ordnance experts give any serious consideration to this theory, which seems to have no basis in fact.

"With regard to the small rapid-fire guns which went through the war, I am quite prepared to learn that a considerable number of them are nearly worn out. Guns like 1, 2 and 3-pound rapid-fires are likely to show serious erosion after firing 2000 rounds, and wherever such service has been approximated we would be disposed to examine the gun with considerable care. In firing such a gun the first serious effect of erosion would be noted in the 'tumbling' of the shell, which would be quite

apparent when the gun was fired. The life of a gun in which nitro-glycerine powder was used would be necessarily shorter than that in which gun-cotton was employed. We have not yet received sufficient data to determine the extent to which the rapid-fire guns approximated the theoretical limit of their efficiency, but I do not think that any very large proportion of them have suffered from the war service."

The ordnance experts are all disposed to make light of the suggestion that the Spanish artillerists kept up frequent firing from the shore in the hope of inducing the American commanders to "wear out their guns" in useless bombardment, thereby rendering them inefficient when brought into play in a naval engagement. "The Spanish," said Captain O'Niel, "did not have ammunition to waste in any such experiment as that suggested, and I think it fair to say they knew too much of ordnance to believe that our guns could be so easily rendered ineffective. W. L. C.—*The Iron Age.*

THE FRENCH NAVAL ESTIMATES.

M. Lockroy has apparently fallen in with the views of experts who argue that the only way of combating England with success is to build light and swift cruisers which will be able to wage war upon the carrying trade, and thus reduce this country to inaction by destroying commerce, for in the list of new vessels which he proposes adding to the French navy, he has comprised specimens which will no doubt satisfy every theorist who has his own ideas on the matter. The list includes seven battle-ships, thirteen cruisers, six station cruisers, two cruisers of a new type that are evidently intended to serve as scouts—the utility of which is being severely criticised in some quarters—one aviso, two gunboats, one transport, eight submarine boats, twelve torpedo-destroyers, one sea-going torpedo-boat, ten squadron torpedo-boats, thirty-nine first-class torpedo-boats, and six small torpedo-boats. Of these vessels thirty-seven will be built in the State dock-yards, and the rest in private yards. Sixteen of the ships in the list are either practically complete or will be at the beginning of next year—that is to say, the battle-ships Charlemagne and Gaulois, the first-class station cruiser Guichen, the second-class cruiser Protet, the aviso Kersaint, which has been on the stocks so many years that it is now thoroughly out of date; the destroyers, Dunois and Durandal, the sea-going torpedo-boat Cyclone, which has recently exceeded thirty knots in its trials at Cherbourg, and nine first-class torpedo-boats. Of the remaining seventy-two vessels, forty-four are either on the stocks or will be by the end of the year. In his statement, M. Lockroy says that both the Saint-Louis and the D'Entrecasteaux will be completed in 1899; but, as a matter of fact, the latter vessel is already completing its armament, and will start for the Chinese seas very shortly. The other ships to be finished next year are the first-class cruiser Chateaurenault, the third-class cruisers D'Estrées and Infernet, eight destroyers, a gunboat, the submarine boat Morse, seventeen first-class torpedo-boats, and six small torpedo-boats. The vessels to be completed in 1900 are the battle-ships Henry IV. and the Iéna, the first-class cruiser Jurien-de-la-Gravière, a gunboat, a submarine boat, and six squadron torpedo-boats. In 1901 are to be terminated the battle-ship Suffren, the protected cruisers Jeanne d'Arc, Dupetit-Thouars, Condé, Montcalm, Desaix, and Kléber;

and in the following year it is announced that the cruisers Gueydon, Gloire, Dupleix, and Sully, will be ready to take the sea. The number of vessels to be put on the stocks in 1899 is twenty-eight, including a battleship, of which the drawings have not even yet been completed, and it is doubtful even whether a definite type has been decided upon; two protected cruisers of the Gloire and Sully class, two estafette cruisers, two destroyers, six submarine boats, four squadron torpedo-boats, and eleven first-class torpedo-boats. The cruisers of the Gloire class will have a displacement of 10,014 tons, with a length over all of 138 metres, and a beam of 20.20 metres, and will be propelled by three screws. The speed is to be 21 knots. Carrying 1590 tons of coal, they will have a range of action of 1940 miles at the maximum speed, and of 10,400 miles at 10 knots. They will have two 194-mm. guns, eight of 164.7-mm., six of 100-mm., eighteen of 47-mm., six of 37-mm., and two of 65-mm. The estimated cost of these two vessels is 21,715,641*f.* and 23,573,500*f.*, the difference being due apparently to the fact that one will be constructed in the State yards and the other by a private firm. The two estafette cruisers, which are of an entirely new type, will have a length of 120 metres, a beam of 13.60 metres, and a displacement of 4000 tons. They will have water-tube boilers, and the engines will develop 15,000 horse-power. The estimated maximum speed is 23 knots. They will have eight guns of 100-mm., twelve of 47-mm., and four of 37-mm., all quick-firing. The estimated cost is 8,766,468*f.* and 8,731,518*f.* respectively. It will be remarked that the submarine torpedo-boats of the type of the Narval, now building at Cherbourg, figure prominently in the estimates, and it appears as if the French Marine have a good deal of confidence in the efficiency of this class of vessel. The six boats to be constructed will have a displacement of 106 tons. They will be propelled by engines of 217 horse-power, and the estimated speed is 12 knots. They will have no other armament but four torpedo-tubes. The cost of each boat is 648,050*f.* The grant M. Lockroy has asked for to cover the year 1899 is 304,078,400*f.*, a matter of 17,000,000*f.* more than for the present year.—*The Engineer.*

SHIPS OF WAR.

[England.]

H. M. S. Argonaut.

The trials of H.M.S. Argonaut, which commenced on the 25th of Nov., came to a satisfactory termination on the 8th inst. The engines of this ship are similar to those of H.M.S. Diadem, of which an illustration was given in a recent issue. The boilers are of the Belleville type, with economizers. The full working pressure is 300-lb. per square inch in the boilers, reduced to 250-lb. per square inch at the engines. The trials consisted of a series of two of thirty hours at 3600 indicated horse-power, one of thirty hours at 13,500 indicated horse-power, and one of eight hours at full power—18,000 indicated horse-power. The second thirty-hour trial at 3600 indicated horse-power was run to confirm the records obtained from the first trial. The following is a tabulated statement of the results of the trials:

	First 30 hours at 3600 I.H.P.	Second 30 hours at 3600 I.H.P.	30 hours at 13,500 I.H.P.	8 hours at 18,000 I.H.P.
Draught of water:				
Forward	24ft. 3in.	24ft. 3in.	24ft. 3in.	24ft. 3in.
Aft	26ft. 3in.	26ft. 3in.	26ft. 3in.	26ft. 3in.
Speed, knots	12.5	13.3	19.5	20.8
Steam pressure in boilers, lb. per sq. in.	226	258	Various	293
Air pressure in stokeholds, in. of water	—	—	—	.21
Vacuum:				
Starboard	24.8	25.8	26.7	25.9
Port	25.4	26.2	26.5	25.4
Revolutions per minute:				
Starboard	74.4	75.5	115.7	128.8
Port	74.8	76.3	116.3	128.0
Mean I.H.P.:				
High, starboard	585	613	2169	2891
High, port	568	570	2138	2869
Intermediate, starboard	470	527	1688	2413
Intermediate, port	466	586	1769	2510
Forward, low, starboard	413	379	1482	1988
Forward, low, port	385	381	1398	1921
Aft, low, starboard	444	403	1683	2319
Aft, low, port	425	356	1488	1983
Total I.H.P.	3756	3815	13,815	18,894
Consumption of coal, lb. per I.H.P.	2.13	2.02	1.6	1.62

Throughout the trials hand-picked Welsh coal was used. Experimental trials were made throughout the series, which showed the evaporation in pounds of water per pound of coal to vary from 10 at low power to 11.2 at full power. At no portion of the trials was there the slightest difficulty, and the Fairfield Company is to be congratulated on the successful results of the trials of this powerful addition to the Royal Navy.—*The Engineer.*

H. M. S. Formidable.

H.M.S. Formidable, launched at Portsmouth on Nov. 17th, is a sister ship to the Implacable, building at Devenport, and the Irresistible, building at Chatham. These vessels, which are described as improved Majestics, were designed by Sir William White, Director of Naval Construction. The new ships are 10 ft. longer than the Majestic, which enables the draught to be reduced by 9 inches without affecting the fighting qualities; the displacement, indeed, is 15,000 tons instead of 14,900 tons. The leading dimensions are as follows: Length between perpendiculars, 400 ft.; beam, 75 ft.; displacement, 15,000 tons; mean draught, 26 ft. 9 in.; indicated horse-power, 15,000; coal capacity, 2100 tons; speed, 18 knots; armament, four 12-in. guns, twelve 6-in. quick-firers, sixteen 12-pounder quick-firers, two 12-pounder 8-cwt. (boat guns), twelve 3-pounder quick-firers, eight Maxims. On a less draught the Formidable carries a greater store of coal, 2100 tons against 1850 tons, and though there is no difference in the weight of armament many improvements in rapidity of fire will be introduced. The Formidable will be propelled by twin screws,

each screw being actuated by a set of triple-expansion engines of 7500 indicated horse-power. Steam will be supplied by 20 Belleville water-tube boilers, working at a pressure of 300 lbs. to the square inch, but the pressure will be reduced at the engines to 250 lbs. At the prescribed draught the ship will carry only 900 tons of coal, but a special feature of this type of vessel, according to the *Times*, is that the lower bunkers can be coaled independently of the upper bunkers. The side armor, which is treated by the improved Harveyed process, will be 9 in. in thickness, 15 ft. in depth, and 216 ft. in length, thus providing a belt for 54 per cent. of the ship's side. The armor bulkheads, varying in thickness from 9 in. to 12 in., will be so fitted as to join the ends of the side armor, forming a complete belt round the vital parts of the ship. There are two protective decks, the principal one being of the turtle-back shape, and the armor will rest upon it at its connection in the shell-plating. It will be 2-in. plating on the flat portion, and 3-in. on the slopes and at the after end. The 12-in. guns will be protected by an 8-in. shield, and the machinery for working the guns will be protected by a 12-in. circular armored redoubt. For the auxiliary armament the Vickers 6-in. quick-firing gun has been adopted, eight being mounted on the main deck and four on the upper deck. Four of these can be fired right forward and four right aft. Each 6-in. gun will be enclosed in a casemate of Harveyed steel, and the ammunition will be sent up through an armored tube, being thus under protection from the time it leaves the magazine. Eight of the 12-pounder quick-firing guns will be carried on the main deck, and the other eight on the upper deck, the 3-pounders being carried in the fighting tops. There will be four 18-in. submerged torpedo-tubes, two being fitted forward and two aft. In order to obviate any serious injury arising from the use of the ram, which is a steel casting weighing more than 30 tons, the sides forward are partly covered with a 2-in. nickel plating in addition to the ordinary skin plating, this stiffening extending from the ram to the belt. If employed as a flagship the Formidable will have a complement of 789 officers and men. She will be fitted with two steel masts, each with a military or fighting top, and with a searchlight platform on the main top-mast. A long-distance semaphore for signalling at sea will be fitted, the semaphore being about 160 ft. above the level of water-line. The masts are provided with three derricks, two forward and one on the mainmast, and these derricks, which are primarily for hoisting out the boats, will be of great utility when coaling. The boats include four steamboats —two 56 ft. in length, and two 40 ft. in length—and 14 sailing and rowing boats, ranging from a 42-ft. sailing launch to a small dinghy. The two larger boats are capable of steaming about 13.5 knots, and are fitted with torpedo-dropping apparatus. They can also act as scouts whilst the parent ship is in harbor. Three independent sets of dynamos and engines are required to light the ship, work the electric motor fans, and for the searchlights. Every compartment except the double bottom will be efficiently lighted by incandescent lamps, and Colomb's lights will be fitted for use when the dynamos are not running. Ventilation will be secured by the use of motor fans outside the engine and boiler-room spaces and by steam fans in these rooms. There will also be a complete installation of electric bells, voice pipes, and loud-speaking telephones at important places. She will be engined by Earle's Shipbuilding Company. Though a 15,000-ton ship, the Formidable will displace only 4500 tons when launched.—*Engineering.*

BRAMBLE.

The gunboat Bramble was launched on the 26th of Nov. from the yard of Messrs. W. H. Potter and Sons at Liverpool. She is one of four vessels of the Thistle class, two of which are being built by Messrs. Potter, and two on the Clyde, the first of which was described fully on page 563 *ante*. The Bramble's length between perpendiculars is 180 ft., and over all 187 ft. 6 in., with 33 ft. beam. At loaded draught of 8 ft. she will have a displacement of 710 tons. She is armed with two 4-in. quick-firing guns, one on the forecastle, and the other on the main deck aft; two 12-pounder quick-firing guns, one on each bow, under the forecastle, and a similar gun on each side amidships. She is also fitted with ten .45-in. Maxims, three on each side of the vessel on the main deck and two in each of the two military fighting tops. Accommodation is provided for officers and crew of 70. She has two sets of triple-expansion engines with an indicated horse-power of 1300.—*Engineering*.

[FRANCE.]

FRENCH BATTLESHIP "CHARLES MARTEL."

We publish on page 556 a general view of the first-class French battleship Charles Martel, and on our two-page plate a section of her main engines, which were constructed by Messrs. Schneider and Co., of Creusot. Further views will be given in a future issue. The Charles Martel was built in 1893, and the following are some particulars of this fine vessel:

Length	120 m. (393 ft. 7 in.)
Beam	22 m. (72 ft. 2 in.)
Draught (aft)	8.40 m. (27 ft. 6 in.)
Displacement	11,882 tons.
Indicated horse-power	13,500
Speed	18 knots.
Number of screws	2
Coal storage	800 tons.

Armor:

Belt	450 mm. (17.72 in.)
Turrets	370 mm. (14.57 in.)
Deck	70 mm. (2.76 in.)

Armament:

Two 305 mm. (12.01 in.); two 274 mm. (10.78 in.); eight 14 cent. (5.51 in.) q.-f.; four 65 mm. (2.56 in.) q.-f.; sixteen 47 mm. (1.85 in.) q.-f.; eight 37 mm. (1.46 in.) q.-f.

The main engines of the Charles Martel are illustrated by our two-page plate; they are vertical, with three cylinders, triple-expansion, of equal power, driving twin screws. The principal dimensions of the engines are the following:

Diameter of high-pressure cylinder	1.130 metre (44½ in.)
Diameter of mean-pressure cylinder	1.700 metre (66$\frac{15}{16}$ in.)
Diameter of low-pressure cylinder	2.680 metre (105½ in.)
Stroke	1.100 metre (43$\frac{5}{16}$ in.)

Each engine is provided with a condensing plant, consisting of a wrought-brass tubular condenser, three vertical single-acting air pumps, and one centrifugal circulating pump. The pumps are worked by a separate engine. The high-pressure slide valves are cylindrical, the mean and low-pressure ones are of the flat type and are balanced. All the slide valves are governed by link motion. The reversing gear can be worked by hand or steam-power. The pistons are of cast steel and are conical in shape. The foundation plates which carry the crankshaft bearings are of cast steel; the columns on which the cylinders are supported are of forged steel. All the crankshafts, intermediate, and propeller shafts are hollow, and of forged steel; the propellers are of special bronze, with blades fitted on. Each engine-room is provided with two ventilators, one for delivering fresh air in the engine-room, and one for exhausting the hot air. The condensed water delivered by the air pumps of each engine is collected in a tank provided with filters, whence it is delivered again into the boilers. Special evaporators serve for producing fresh water to make good the loss. There are 24 boilers of the Lagrafel and d'Allest type, as prescribed for this battle-ship, placed in four stokeholds; the boilers being connected with two funnels.

Registered steam pressure.....	15 kilos. (213.3 lb. per sq. in.)
Total grate area	95.20 sq. m. (1024.8 sq. ft.)
Total heating surface including that not covered by water	3000 sq. m. (32,292 sq. ft.)

The boilers are fed by eight Thirion pumps, worked by separate engines. The ventilation of the stokeholds and the forced draught are provided for by eight fans.

The maximum total power prescribed was 13,500 horse-power, at 95 revolutions, with a maximum steam pressure of 12 kilogrammes (170.7 lb. per square inch) in the steam chest. The trials gave the following results:

Duration of trial, hours.....	6	6	4	24	6
Number of engines working.....	2	2	2	2	2
Number of boilers working.....	8	16	24	24	24
Average revolutions	52.4	70.5	97	87.5	92.7
Total horse-power	2186	5545	14,931	9800	12,620
Coal consumption per horse-power per hour, kilogs	0.762	0.624	0.796	0.753	0.736
Coal consumption per horse-power per hour, lb.	1.68	1.38	1.76	1.67	1.63

—*Engineering.*

The French Battle-ship Bouvet.

The Bouvet, which is an improved Charles Martel, which again is an improved Jauréguiberry, is the largest and finest ironclad at present in the French navy. She was laid down in January, 1893, launched in April, 1896, and completed for sea early in this present year.

The armament comprises two 12-in. guns in turrets for and aft; two 27-centimetre—10.8-in. exactly—in turrets, one on either beam; eight 6-in. quick-firers, in eight separate turrets; eight 4-in. quick-firers, disposed upon the upper deck behind shields of hardened steel; twelve 3-pounder quick-firers; and twenty 1-pounder quick-firers.

There are three above-water and two submerged torpedo-tubes—one of the former in the stern. The 12-in. guns are 40 calibres long and 46 tons in weight. The velocity is very high, 2625 both for these and for the 27-centimetre guns, consequently excellent shooting is made with them. The 27-centimetre guns are 45 calibres in length. The nominal muzzle energies are respectively 30,750 foot-tons and 22,750 foot-tons. Both sorts are in the first rank of armor-piercing guns, and have a penetration equal to most armor afloat at near range. Roughly, the actual service penetrations at 2000 yards may be put at 24-in. and 18-in. of iron respectively. We have in the plan adopted the naval war game system of gun and armor notation. By this all guns and armor are reduced to a single-lettered approximation based on what, roughly, the gun can penetrate with armor-piercing shot at 2000 yards, the index letter to the armor signifying that it is proof against any gun of an inferior letter. Thus *b* armor must be attacked by a B or A gun. For hasty reference this system is convenient, and presumably approaches the actual sufficiently nearly for practical purposes.

The armor of the Bouvet is distributed as follows: A complete belt, the top of which is on the water-line 16-in. to 8-in. Creusot steel, which is equivalent to Harvey armor in resisting power. Behind this belt is a 3½-in. deck, curved like that of the Majestic, which gives a further resisting value equal to about 12-in. vertical iron armor. Consequently the engines have a protection altogether equivalent to vertical iron armor 44-in. thick or more. Even the gun tables allow this as muzzle penetration to very few guns, in actual practice we may safely say nothing could possibly get through it. Fairly safely, too, we may call this excessive protection a waste of armor that could better have been placed elsewhere. Below, again, is a splinter deck. Above this thick belt, covering up to the base of the main deck forward and to a similar height under the amidship turret nest, elsewhere about 3 ft. above the water-line, on a level with the top of the armor-deck, is a thin belt 4-in. thick. This belt is incomplete, stopping some 50-ft. from the stern in the Bouvet, though the other ships of the class have it complete.

The big gun turrets have 14½-in. armor. Their bases are unprotected, but the hoists are about 4-in. thick—the exact thickness of these is doubtful. The turrets revolve around these hoists. The weak point of the design is the havoc a big shell would wreak bursting anywhere under these turrets. The small turrets and their hoists are all 4-in. thick—susceptible to 6-in. solid shot—a weak point again. The shields for the 4-in. guns are about 2-in. thick of special hardened steel. There are three conning towers, one at the base of each mast and one abaft the after funnel; all have about 10-in. of armor. Melenite shell are carried for all guns of 4-in. and over in the Bouvet.

The target she offers is very big. It is very problematical how the 4-in. guns would fare in action. The illustrations indicate clearly the positions of the guns. A weak point in the Bouvet, which French critics draw attention to, is the amidship west of turrets. There seems a strong chance that one single shell, of no very large calibre, bursting under the central turret would jam all three. On the other hand, the ship's fighting position is at an angle, and in such case the base of the big upper turret is well enough protected by its smaller companions.

The Bouvet has three sets of triple-expansion engines, each actuating a screw. The boilers are of the Belleville type. The ship has done so

many trials that it is difficult to select any one result as her "trial speed," a mean of 18 knots has been frequently obtained. The twenty-four hours' trial, at sea with the ship at her proper displacement, produced from 17 to 17.5 knots. This is very good, indeed. Our only battle-ship able to equal it is the Renown, which has lately been cruising at 17 knots; but the Renown, with her inferior big guns, would not stand a very good chance against the Bouvet: she would be powerless, that is, against the Frenchman's armor, while her own would be liable to penetration at 4000 or even 5000 yards. On the other hand, the Bouvet is ill-adapted to stand shell fire. Like nearly all French ships, the Bouvet could not be sunk by gun-fire, but shell might wreck her all to pieces. Ours are in more danger, speaking generally, of being sunk than wrecked by gun-fire. There is a suggestive proverb about this in our service; but at the present time of heated sentiment it need not be repeated. It suggests reflection, however.—*The Engineer.*

The French Battleship Massena.

The Massena carries an armament identical with that of the Bouvet, fully described last week—two 12-in., two 10.8-in., eight 5.9-in. quick-firers, and eight 4-in. quick-firers. The latter guns are, however, carried quite differently, and possibly better placed. Having the large French ram bow, the Massena differs a good deal from the Bouvet in general appearance, and her design having been worked out independently of that ship there are other differences of details also. The boilers are Lagrufel D'Allest—the Bouvet has Belleville. The funnels of the two ships are very differently placed, and the Massena has a large number of big cowls, the Dupuy de Lôme being the only ship that approaches her in this respect. On trial the Massena made very near 18 knots, but the enormous bow wave caused trouble. She has, however, run 17 knots continuously at sea. The armor of the Massena is identical with that of the Bouvet, save in one particular—the belt aft is incomplete.

[Russia.]

General Admiral Apraksin.

The second trial of the engines of the Russian coast defence battle-ship General Admiral Apraksin has taken place with good results. The warship made four runs on the measured mile, and the mean speed realized was 15.07 knots. During a seven hours' continuous run of the engines at full power, no interruption in the regularity of the working was observed. During the trial nine sets of diagrams were taken, and these indicate that the engines on this occasion realized more than the 5000 horse-power required by the contract. The indicated horse-power, as shown by the ninth sets of diagram was as follows: Port engine, high-pressure cylinder, 806.17; intermediate, 997.80; low, 1028.60; total, 2832.57. Starboard engine, high-pressure cylinder, 817.63; intermediate, 1026.78; low, 1080.42; total, 2924.83. The number of revolutions of the port engine was 123, and the pressure of steam 128.4 lb.; of the starboard engine, revolutions, 124; pressure of steam, 133.2 lb. The grand total indicated horse-power was 5757.40. At the first trial the indicated horse-power fell short of that contracted for, and the contractors at the Franco-Russian works became subject to a fine of 2920*l.* The makers attribute the deficiency of

the indicated horse-power to the incapacity of the stokers who were employed at the trial.—*Engineering.*

PETROPAVLOVSK.

Details have also been received of the trials of the Russian battle-ship Petropavlovsk. This was also the second trial, the previous one failing owing to a defect in the low-pressure cylinder of the starboard engine. The following are the details: Draught, bow, 24 ft. 4 in.; aft, 26 ft. 4 in.; mean 25 ft. 4½ in.; displacement, 10,890 tons. The mean of runs on the measured mile was 16.38 knots. The indicated horse-power was, port engine, high-pressure cylinder, 1619.5; intermediate, 2046; low, 1922; total, 5587.6; starboard engine, high-pressure cylinder, 1666.4; intermediate, 2011.7; low, 1947.4; total, 5625.5. Gross total indicated horse-power, 11,213; revolutions of screw, 84; steam pressure, 120 lb.—*Engineering.*

[UNITED STATES.]

WAR VESSELS UNDER CONSTRUCTION.

A statement prepared by Philip Hichborn, chief of the Naval Construction Bureau, shows that on November 1 there were under construction for the navy in various ship-yards 55 vessels, by far the largest number ever undertaken at one time in this country. There are eight battle-ships, and of these the "Kearsarge," at Newport News, Va., has advanced 71 per cent. toward completion, while her sister ship, the "Kentucky," at the same place, has a percentage of 69. The "Illinois" is 57 per cent. and the "Alabama" 65 per cent., at the Cramp yards, in Philadelphia, and the "Wisconsin," at the Union Iron Works, San Francisco, 52 per cent. completed. The sheathed cruiser, "Albany," which the United States bought on the stocks in England, is exactly half finished. The 22 torpedo-boats under contract show percentages of completion ranging from nothing to 99, the latter in the case of the "Rowan," at Moran Brothers' yard, Portland, Ore. The submarine boat "Plunger," at the Columbian Iron Works, Baltimore, is advanced 85 per cent., and the training ship "Chesapeake," at the Bath Iron Works, Bath, Maine, 35 per cent.—*The Iron Age.*

Absolutely pure is the claim made in every advertisement of the Royal Baking Powder and absolutely pure is the verdict of every housekeeper in the land using the Royal. It is the standard among baking powders, worth the price sold at, because of its purity, healthful bread-making qualities and the strength that makes a small quantity go a long way. No trouble about delicious biscuit and pastry when the Royal is used.

BOOK NOTICES AND REVIEWS.

TĖORIA VĖROYATNOSTIE I PRĖMĖNENIA ĖA K'STRĖLBĖ I PRĖSTRĖLBĖ.

THEORY OF PROBABILITIES AND ITS APPLICATION TO FIRING AND REGULATION OF AIM, by Colonel N. Zaboudski, Permanent Member of the Artillery Committee, Professor in Ordinary at the Michaelovsk Artillery School, Pub. Saint Petersburg, Press of the Imperial Academy of Science, 1898.

This work constitutes the second half of Colonel Zaboudski's treatise upon Exterior Ballistics, the first portion of which appeared in print about a year ago. In an octavo volume of 400 pages, are discussed at length those theorems in probabilities applicable to the classification and evaluation of groups of experimental data obtained as the results of gun-firing. The scope and nature of Colonel Zaboudski's treatise are clearly set forth in its preface, a translation of which is hereto appended, as illustrating the character of the work.

"The theory of probabilities and its application to firing and to the regulation of aim constitute the 2nd section of the course taught by me at the Michaelovsk Artillery Academy. The subject is here developed to such an extent as to afford artillerists a means of acquaintance with the fundamental principles of the theory of probabilities, through the method of least squares, and by processes convenient for the investigation of results of firing and pointing."

"The work is subdivided into five chapters and five appendices."

"In Chapter I the fundamental principles of the theory of probabilities are stated; my exposition of them is based in the main upon notes made by me at the lectures of the Academician P. L. Tchebishev, which I attended in 1880-81, at the St. Petersburg University."

"Chapter II discusses the method of least squares; in preparing it I have utilized General Maievski's work, 'Exposition of the Method of Least Squares,' 1881, supplemented by a few theorems. The proof of the principle of the arithmetical mean for a very great number of observations, is based upon Tchebishev's theorem, while a second proof of this principle is also deduced, based upon the determination of the probability, that the sum of the observed values lies between given limits; by this it is shown that the most probable value of the unknown quantity is the arithmetical mean of the observed values."

"The proof of the principle of the arithmetical mean for a very great number of observations is independent of the form of the function expressing the probability of error of observation. The form of this function is determined on the assumption of Gauss, that the most probable hypothesis relating to the quantity under measurement corresponds to the arithmetical mean of its observed values. Upon this assumption is based the solution of various problems related to the method of least squares."

"The Chapter concludes with the presentation of explanatory numerical examples, one of which is connected with ordnance investigation, namely, the preparation of the data resulting from firing the 4.2 gun provided with side pressure gauges for measuring pressures developed by smokeless powder gases at various sections of the bore."

"In Chapter III the theory of probabilities is employed for the study of results, from firing solid shot and shrapnel."

"The chance of deviation of a projectile from the centre of grouping upon a plane and in space, is deduced in accordance with the assumption of Bravais and Schols,* that the causes producing the deviation of a projectile from the center of grouping are very many, and that all may produce deviation indiscriminately in any direction. Such a method of determining the chance of deviation of a shell was followed by the Italian Major of Artillery (now Senator) Siacci, and the French General of Artillery Pioutz in investigating the results of firing."

"In order that deductions based upon the principle of the arithmetical mean may be applied to correcting results of observations it is necessary to equate directly results from practice with those deduced theoretically. Examples are adduced from various authors illustrating the possibility of applying the method of least squares to the investigation of the results of firing; in addition thereto I have presented my own study, in accordance with this method, of data obtained from firing the 12-cm. (4.72-in.) heavy siege gun at the Krupp works, Dec. 1880. The tables of the French artillerist Lardillon, are employed for determining the number of hits resulting from firing a group of shrapnel."

"Chapter IV treats of the employment of the theory of probabilities for investigating problems for the regulation of firing. This chapter is a rearrangement of lithographed notes prepared by me in 1880 for use at the Michaelovsk Artillery Academy, in compiling which I utilized the investigations of the French artillerist Persain, the Belgian artillerist Mangon, and articles by Lieut.-Gen'l Shklarevitch."

"In the solution of problems relating to the correction of fire the cases of shell with percussion fuses and of shrapnel are both considered."

"The correction of aim can only be based in most cases upon the knowledge of the direction of deviation of the shell from the target, but in fortress and siege firing, cases may be met where the correction of aim is based upon actual measurement of such deviation. Two methods of correction are therefore to be considered; (1) that based upon measurements of deviation, (2) that based upon the ratio of shorts to overs. Persain and Mangon's method is employed for the investigation of the latter case. Mangon's method is also applied to the case where the firing is corrected by measuring the deviation of one group of shots, and by determining the ratio of shorts to overs for another."

"Errors in observation are taken into account in the correction of firing; and the chances of firing short and over are discussed for the case where such an error is recognized."

"For illustrating the application for theoretical method to the correction of aim, some of the rules adopted by us for firing at a moving target are discussed."

"Chapter V presents Tchebishev's formulae for interpolation by the method of least squares as applied to the solution of normal equations

*Professor at the Delft. Polytechnic School. Note upon Probability in Firing. Revue d'Artillerie, Feb., 1884.

by the aid of indeterminate coefficients, followed by examples taken from the French artillerist Jouffré."

"*Appendix I* presents the development sin x in infinite series in x.*"

"*Appendix II* gives the integration of the expression representing the degree of accuracy of observations in terms of the nth degree of the errors."

"In *Appendix III* is presented Laplace's corollary, that for a very great number of observations the most probable value of the unknown quantity, expressed in equations is determined by the method of least squares, independently of the form of the function expressing the chance of error in observation, and based upon the two first theorems of the theory of probabilities—summation and multiplication."

"*Appendix IV* contains deductions based upon the rule of mean value. In consequence of the investigations of the French artillerist Etienne, articles have appeared in our ordnance literature that do not elucidate this rule with sufficient clearness; I therefore discussed Etienne's work, and expounded those scientific deductions relating thereto."

"The rule of mean value has long been known, but its employment ceased upon the discovery of the method of least squares, in view of the indisputable superiority of the latter method."

"*Appendix V* consists of tables."

$$*\text{Sin } x = x\left(1-\frac{x^2}{\pi^2}\right)\left(1-\frac{x^2}{2^2\pi^2}\right)\left(1-\frac{x^2}{3^2\pi^2}\right)\cdots$$

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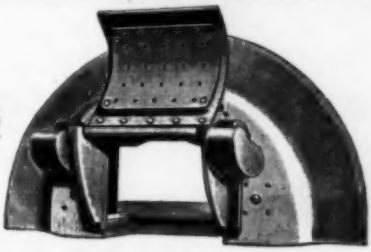

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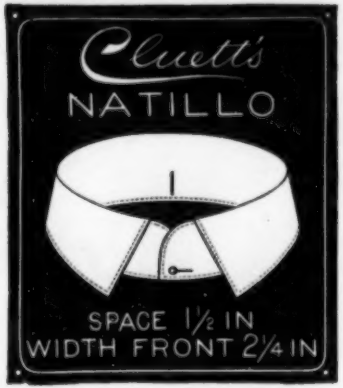

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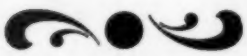

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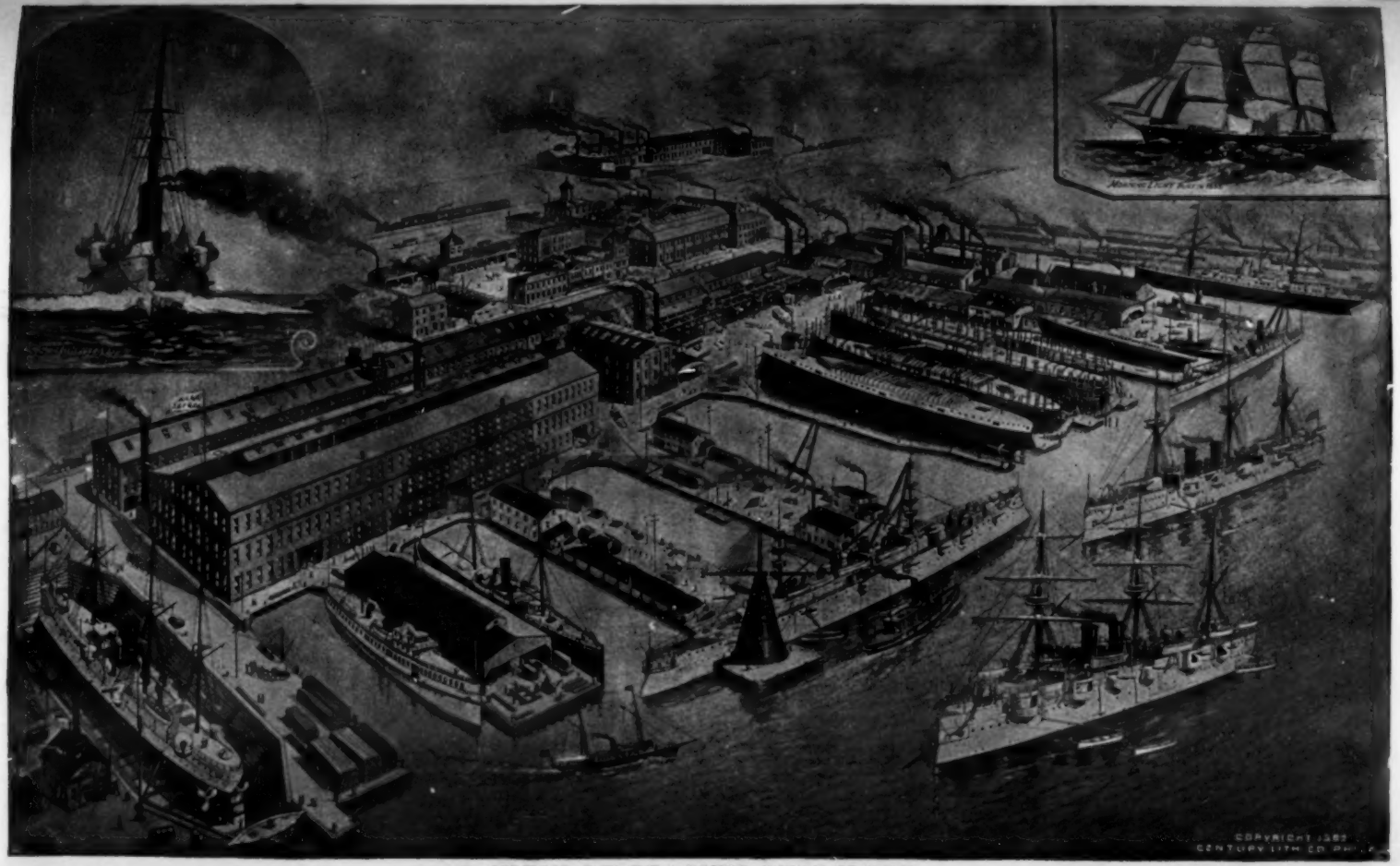

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NOTICE.

The U. S. Naval Institute was established in 1873, having for its object the advancement of professional and scientific knowledge in the Navy. It now enters upon its twenty-sixth year of existence, trusting as heretofore for its support to the officers and friends of the Navy. The members of the Board of Control cordially invite the co-operation and aid of their brother officers and others interested in the Navy, in furtherance of the aims of the Institute, by the contribution of papers and communications upon subjects of interest to the naval profession, as well as by personal support and influence.

On the subject of membership the Constitution reads as follows:

ARTICLE VII.

Sec. 1. The Institute shall consist of regular, life, honorary and associate members.

Sec. 2. Officers of the Navy, Marine Corps, and all civil officers attached to the Naval Service, shall be entitled to become regular or life members, without ballot, on payment of dues or fee to the Secretary and Treasurer, or to the Corresponding Secretary of a Branch. Members who resign from the Navy subsequent to joining the Institute will be regarded as belonging to the class described in this Section.

Sec. 3. The Prize Essayist of each year shall be a life member without payment of fee.

Sec. 4. Honorary members shall be selected from distinguished Naval and Military Officers, and from eminent men of learning in civil life. The Secretary of the Navy shall be, *ex officio*, an honorary member. Their number shall not exceed thirty (30). Nominations for honorary members must be favorably reported by the Board of Control, and a vote equal to one-half the number of regular and life members, given by proxy or presence, shall be cast, a majority electing.

Sec. 5. Associate members shall be elected from officers of the Army, Revenue Marine, foreign officers of the Naval and Military professions, and from persons in civil life who may be interested in the purposes of the Institute.

Sec. 6. Those entitled to become associate members may be elected life members, provided that the number not officially connected with the Navy and Marine Corps shall not at any time exceed one hundred (100).

Sec. 7. Associate members and life members, other than those entitled to regular membership, shall be elected as follows: Nominations shall be made in writing to the Secretary and Treasurer, with the name of the member making them, and such nominations shall be submitted to the Board of Control, and, if their report be favorable, the Secretary and Treasurer shall make known the result at the next meeting of the Institute, and a vote shall then be taken, a majority of votes cast by members present electing.

The Proceedings are published quarterly, and may be obtained by non-members upon application to the Secretary and Treasurer at Annapolis, Md. Inventors of articles connected with the naval profession will be afforded an opportunity of exhibiting and explaining their inventions. A description of such inventions as may be deemed by the Board of Control of use to the service will be published in the Proceedings.

Single copies of the Proceedings, $1.00. Back numbers and complete sets can be obtained by applying to the Secretary and Treasurer, Annapolis, Md.

Annual subscriptions for non-members, $3.50. Annual dues for members and associate members, $3.00. Life membership fee, $30.00.

All letters should be addressed to Secretary and Treasurer, U. S. Naval Institute, Annapolis, Md., and all checks, drafts and money orders should be made payable to his order, without using the name of that officer.